User's Manual

Fast — Easy — Reliable

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More information about ActivVisionTools can be found at:

`http://www.activ-vision-tools.com`

How to Read This Manual

This manual explains how to use ActivDataCode to read 2D data codes. It describes the functionality of ActivDataCode and its cooperation with other ActivVisionTools with Visual Basic examples. Before reading this manual, we recommend to read the manual Getting Started with ActivVisionTools, which introduces the basic concepts of ActivVisionTools and the User's Manual for ActivView to learn how to load and display images.

To follow the examples actively, first install and configure ActivVisionTools as described in the manual Getting Started with ActivVisionTools. For each example in this manual, there is a corresponding Visual Basic project; these projects can be found in the subdirectory `examples\manuals\activdatacode` of the ActivVisionTools base directory you selected during the installation (default: `C:\Program Files\MVTec\ActivVisionTools`). Of course, you can also create your own Visual Basic projects from scratch.

We recommend to **create a private copy of the example projects** because by experimenting with the projects, you also change their *state*, which is then automatically stored in the so-called description files (extension `.dsc`) by ActivVisionTools. Of course, you can restore the state of a project by retrieving the corresponding description file from the CD.

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Chapter 1

About ActivDataCode

This chapter will introduce you to the features and the basic concepts of ActivDataCode. It gives an overview about ActivDataCode's *master tool* and its *support tools*, which are described in more detail in chapter 2 on page 7 and chapter 3 on page 27.

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1.1 Introducing ActivDataCode

ActivDataCode enables you to develop applications to read various common data codes. The tool finds data codes in your images and decodes them. It returns the decoded data along with additional information about the data codes. Following the tradition of its sibling tools, it is easy to set up and employ. Furthermore, it is powerful enough to be used for advanced applications.

Basics

A data code is a symbol with a certain meaning, just like a letter or an icon. There are data codes that represent the number '42', and there are data codes that represent the Japanese translation of The Fool on the Hill by The Beatles. Most letters or icons have been designed to be perceived by humans. In contrast, data codes have been designed to be easily readable by the 'eyes' of machines, namely cameras and specialized scanners.

In this regard, they are very similar to bar codes which also encode information in a way that makes it easy for machines to decipher. What separates them is the amount of information that can be encoded without the symbol getting too big in size as well as the reliability with which even defective data codes can be decoded.

In general, data codes are used in applications where a significant amount of information is to be associated with objects. Plus, the information needs to be in place, i.e. printed on or punched into the object. Otherwise, it would be sufficient to label the object with a product code, and look up the associated information in a data sheet or database, which is typical for applications based on bar codes.

Concepts

There are different types of data codes. Whereas bar codes encode the information as an alternating pattern of black and white along a line, data codes add an additional dimension, storing the information in a grid or matrix. The elements or cells that form this matrix are referred to as *modules*. These modules carry binary information. They can be set or unset. In this manual, unset modules will be referred to as *zero modules*. By default, a dark module is considered to be set, whereas a light module marks an unset bit. This is referred to as the *polarity* of a data code. In some cases, the polarity is inverted, which is something the data code reader must be able to deal with.

From what has been said before it should be clear why data codes are also frequently called 2D bar codes. The fact that bar codes are also printed in two dimensions should not confuse you. The vertical dimension is only used for redundancy; the encoded information in this direction is identical.

While most of the modules of a matrix data code do encode the actual data, there are some modules that invariably appear at the same position in any data code of the same type. They

Figure 1.1: Components of the supported matrix data codes.

build a specific pattern which makes it easy to find the data code in an image. Once detected, they uniquely determine the orientation of the data code and act as the reference anchor for the data section. This static pattern is called *finder pattern*.

Apart from the finder pattern, a data code is required to be surrounded by a uniform region to simplify its detection and to keep background noise from disturbing the decoding. This uniform region is called *quiet zone*.

There are also hybrid types of data codes, which are composed of multiple bar codes with the addition of efficient error correction and enclosed by start and stop patterns. Imagine setting the words of this paragraph in one single line. It would make this manual appear rather bulky. Because bar codes that encode a lot of information tend to get rather big as well, it occurred to some people that they could just as well cut this strip of information into pieces of equal size, and stack them up line by line. Data codes following this approach are called *stacked codes*.

Supported Data Code Types

ActivDataCode supports both matrix and stacked data codes. In the former category both Data Matrix ECC 200 and QR Code (models 1 and 2) data codes are supported. In the latter category, the PDF417 (Portable Data File) data code is supported (both conventional and compact/truncated). Example images of these data code types are shown in figure 1.1 and figure 1.2.

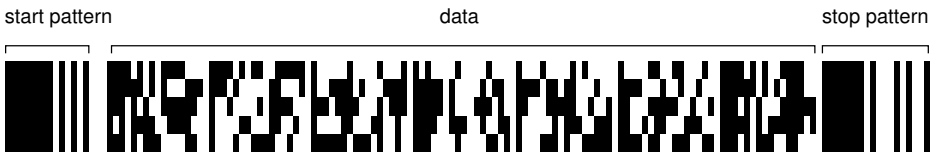

Figure 1.2: Components of the PDF417 stacked data code.

Application

In most applications, ActivDataCode reads data codes automatically without the need to adjust tons of parameters. Even if the detection fails in some images, a teaching facility will usually optimize the decoding process automatically. But even seemingly hopeless images of poor quality may be decoded by applying preprocessing filters to them. Detailed descriptions can be found in the following chapters.

A data code can appear in any position and any orientation. Furthermore, data code extraction with ActivDataCode is very robust. It extracts data codes even from difficult backgrounds and in case of varying illumination. ActivDataCode can also be instructed to read several data codes at once from the same image provided they are of the same type. To speed up the extraction, you can specify regions of interest (ROIs). By default, ActivDataCode will offer to create an ROI that covers the entire image. If you want to decode data codes of different type in the same application, you will have to add multiple ActivDataCode tools.

Results

The result of ActivDataCode is, of course, the content of the extracted data code. Furthermore, ActivDataCode lets you output additional information (also called *features*), e.g., the position of the data code in the image (see figure 1.3), the appearance, or the actual (sub)type of the data code. You can also request results concerning the print quality of the data code (see appendix A on page 51 for more information). The results of ActivDataCode can be further evaluated using ActivDecision, before you output them via ActivFile, ActivSerial, or ActivDigitalIO; furthermore, you can access results via the programming interface (see section 4.3 on page 40).

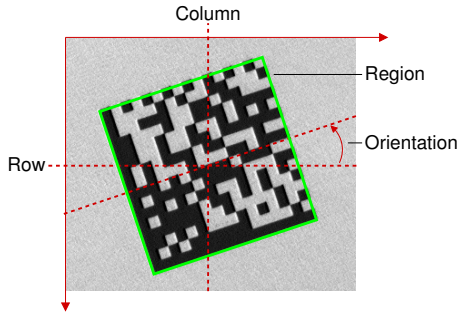

Figure 1.3: The position of a data code in the image.

1.2 The Sub-Tools of ActivDataCode

Besides its *master tool*, ActivDataCode provides three *support tools*. In figure 1.4, the basic tools are depicted together with other ActivVisionTools that you will use in a typical ActivDataCode application. In figure 1.5 on page 6, the tools for advanced data code applications can be seen.

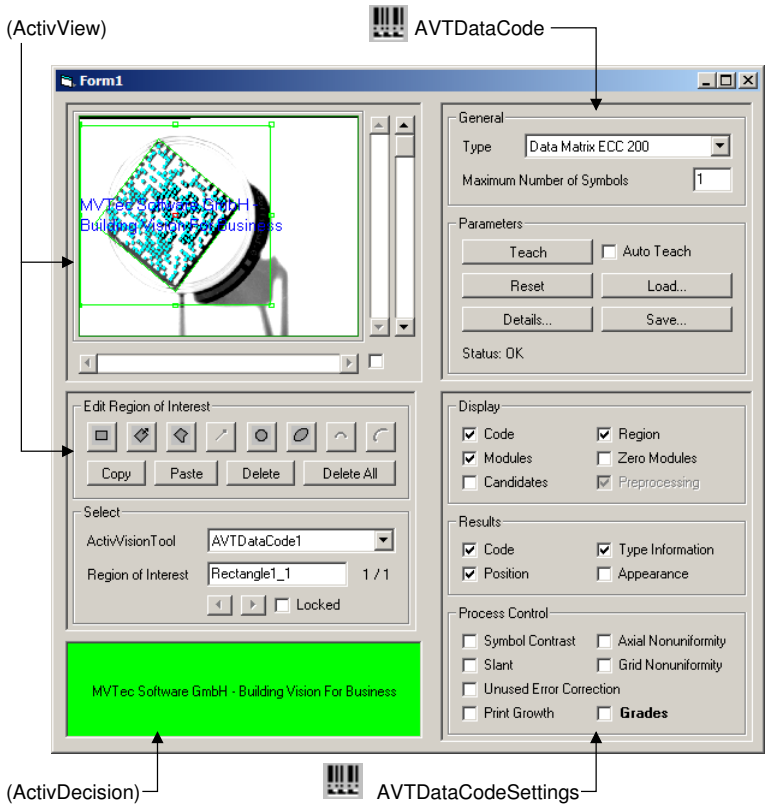

Figure 1.4: The basic sub-tools of ActivDataCode together with suitable other tools.

`AVTDataCode` is the *master tool* of ActivDataCode. In it, you specify the expected type of data code and the number of symbols to be decoded. If a data code cannot be detected using the standard settings, you can ask ActivDataCode to adjust its internal parameters until the detection succeeds. This is referred to as teaching a data code. The taught parameters can be saved to disk for later use. How to use `AVTDataCode` is described in more detail in section 2.2 on page 10.

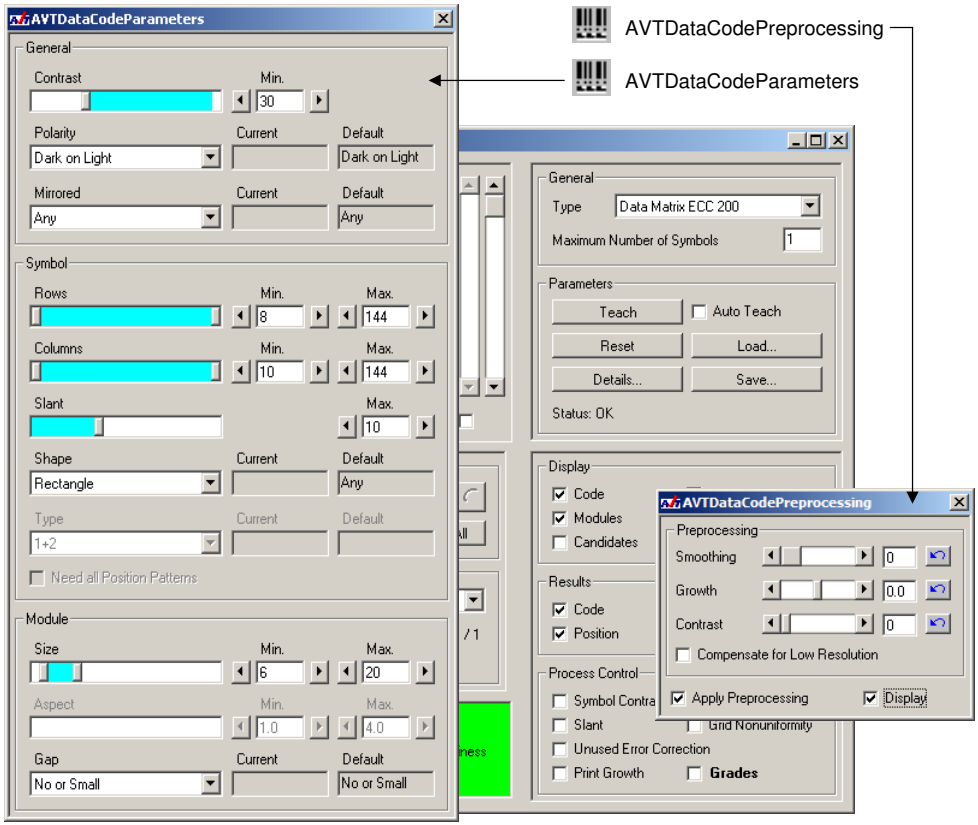

Figure 1.5: The advanced sub-tools of ActivDataCode .

`AVTDataCodeSettings` is a *support tool* of ActivDataCode. With it, you can set up what is to be displayed in ActivView, and what results are to be calculated for ActivDecision. How to use `AVTDataCodeSettings` is described in section 2.2 on page 10.

`AVTDataCodePreprocessing` is a *support tool* of ActivDataCode. It allows to apply image preprocessing to the ROI, in order to enable or improve the decoding of data codes under bad conditions. How to use `AVTDataCodePreprocessing` is described in section 2.5 on page 22.

`AVTDataCodeParameters` is a *support tool* of ActivDataCode. It allows to manually tweak the parameters of ActivDataCode for advanced applications. How to use `AVTDataCode-Parameters` is described in section 2.4 on page 14.

Chapter 2

Using ActivDataCode

This chapter will explain how to use ActivDataCode to read various types of data codes and how to "tune" the underlying image processing.

The corresponding Visual Basic projects show how to successfully read data codes.

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2.1 Specifying Regions of Interest Using

ActivDataCode lets you choose between different shapes of ROIs, e.g., arbitrarily oriented rectangles or ellipses. You create an ROI using `AVTViewROI`, which is a *support tool* of ActivView.

Visual Basic Example

Preparation for the following example:

- ☐ Open the project `rois\datacode_rois.vbp`. Alternatively, create a new project and place the following tools on the form (in parentheses the icon you have to double-click with the left mouse button): `AVTView` ( ), `AVTViewROI` ( ), and `AVTDataCode` ( ).
- ☐ Execute the application (`Run` ▷ `Start` or via the corresponding button). Open `AVTViewFG` by clicking into `AVTView` with the right mouse button and selecting `Image Acquisition` in the popup menu. Load the image `datacode\qrcode\qr_hd_01` via the combo box `Input File`.

The following steps are visualized in figure 2.1.

① First, you have to tell `AVTViewROI` to create an ROI for ActivDataCode by selecting the corresponding entry in the combo box `ActivVisionTool`. In this box, all ActivVision-Tools are listed that have been placed upon the form. By default, the tools are referenced by the name of the corresponding ActiveX control plus a counter to distinguish between multiple instances of a control on the form, e.g., `AVTDataCode1`. If there is only one tool, it is selected automatically.

② Next, select the desired shape of the ROI, for example a rectangle.

③ To draw the ROI, move the mouse in the image while keeping the left mouse button pressed. Please experiment at this point with the different shapes.The creation of a polygonal ROI ( ) is more complex: By the first mouse movement, the first side of the polygon is created. You can add a new corner point by clicking on the line with the left mouse button; when you drag it by keeping the mouse button pressed, new polygon sides are created, where you can again add new corner points. To delete a corner point, drag it onto a neighboring corner point.

If the data code moves from image to image, we recommend to enlarge the ROI accordingly.

④ You can now move the ROI by dragging its pick point in the middle. By dragging the outer pick points you modify its shape. Again, please experiment to get familiar with the ROIs. Note that for a polygonal ROI the “middle point” appears at the center of gravity of the ROI and therefore changes whenever the polygon is modified; besides, it

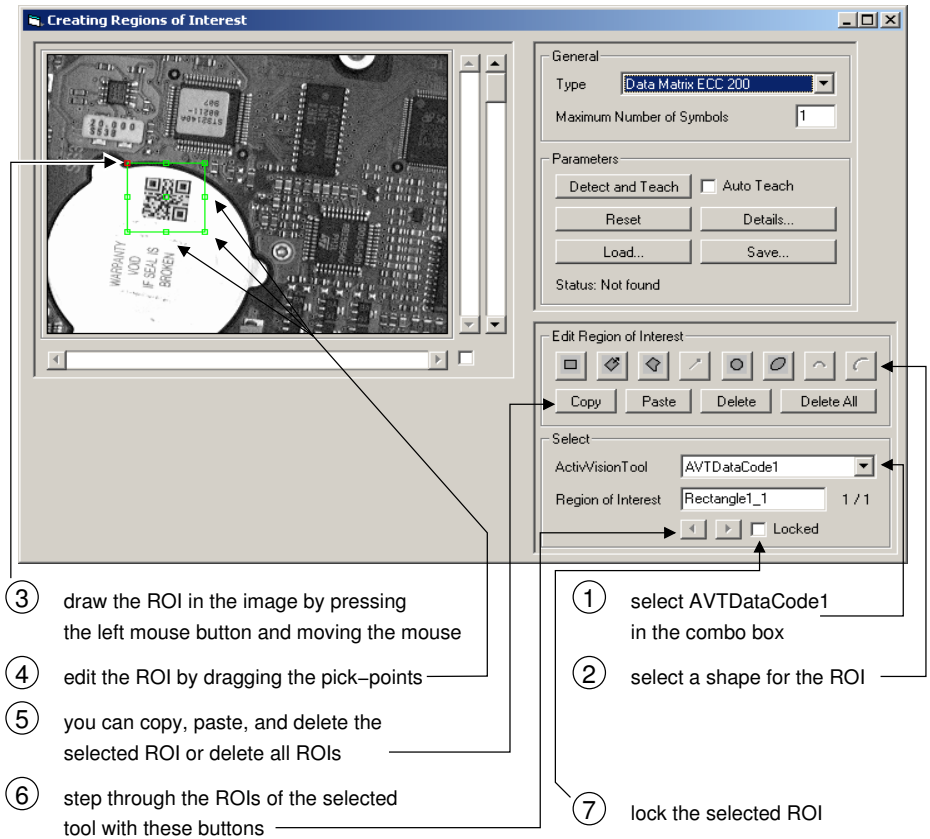


Figure 2.1: Creating a region of interest.

may even lie outside the ROI for concave polygons.

(5) To create a second ROI, repeat step (2). You can also copy, paste, and delete the selected ROI or delete all ROIs.

(6) ROIs can be selected by clicking next to them in the image. Alternatively, use the two arrow buttons to step through all the ROIs of the selected tool.

(7) By checking ☑ `Locked` you can lock the selected ROI in place and thus prevent it from accidental editing or deletion.

If there are multiple data codes of the same type in an image, you can either create one ROI that contains them all, or multiple ROIs containing one or more data codes.

2.2 Reading Data Codes Using

While you are positioning an ROI on the image, ActivDataCode already tries to find a data code of the currently selected type inside it. The default setting of ActivDataCode is to look for ECC 200 data codes. Using `AVTDataCode`, you can setup the data code type of your application. With `AVTDataCodeSettings` you can configure the output behavior of ActivDataCode.

Visual Basic Example

Preparation for the following example:

- ☐ If you worked on the previous example, you may continue using this project. At design time, add `AVTViewStatus`, `AVTDataCodeSettings`, and `AVTDataView` by double-clicking , , and . You may delete `AVTViewROI`, as it can be opened at run time by clicking into `AVTView` with the right mouse button and selecting `Region of Interest`.

  Otherwise, open the project `reading\datacode_reading.vbp`.

- ☐ Execute the application (`Run` ▷ `Start` or via the corresponding button) and open `AVTViewFG` by clicking into `AVTView` with the right mouse button and selecting `Image Acquisition` in the popup menu. Select the image `datacode\qrcode\qr_hd_01` in the combo box `Input File`.

The following steps are visualized in figure 2.2.

① Specify the data code type in the combo box `Type`. In the example image, a *QR Code* is displayed. If you do not know the type of the data code, you can look up the supported data codes in figure 1.1 on page 3. The supported data codes can be distinguished easily by looking at the finder pattern.

② If the ROI is correctly placed around the data code (including the quiet zone), the read code should now be displayed in `AVTView`. If `AVTDataCode` fails to extract a data code, `AVTDataCode` will display a corresponding message.

③ With the help of check boxes, you can specify what is to be displayed on the image: the decoded *data* of the data code, the image *region* corresponding to the data code (excluding the quiet zone). You can also display both the foreground and the background (zero) *modules*. Especially with difficult images, it can be helpful to display all the *candidates* that are evaluated by ActivDataCode. Section 4.1 on page 36 explains how to change the appearance of the displayed results.

④ Besides the extracted data code, ActivDataCode can output additional information (also called *features*), e.g., the position of the data code. The process control features are explained in appendix A on page 51.

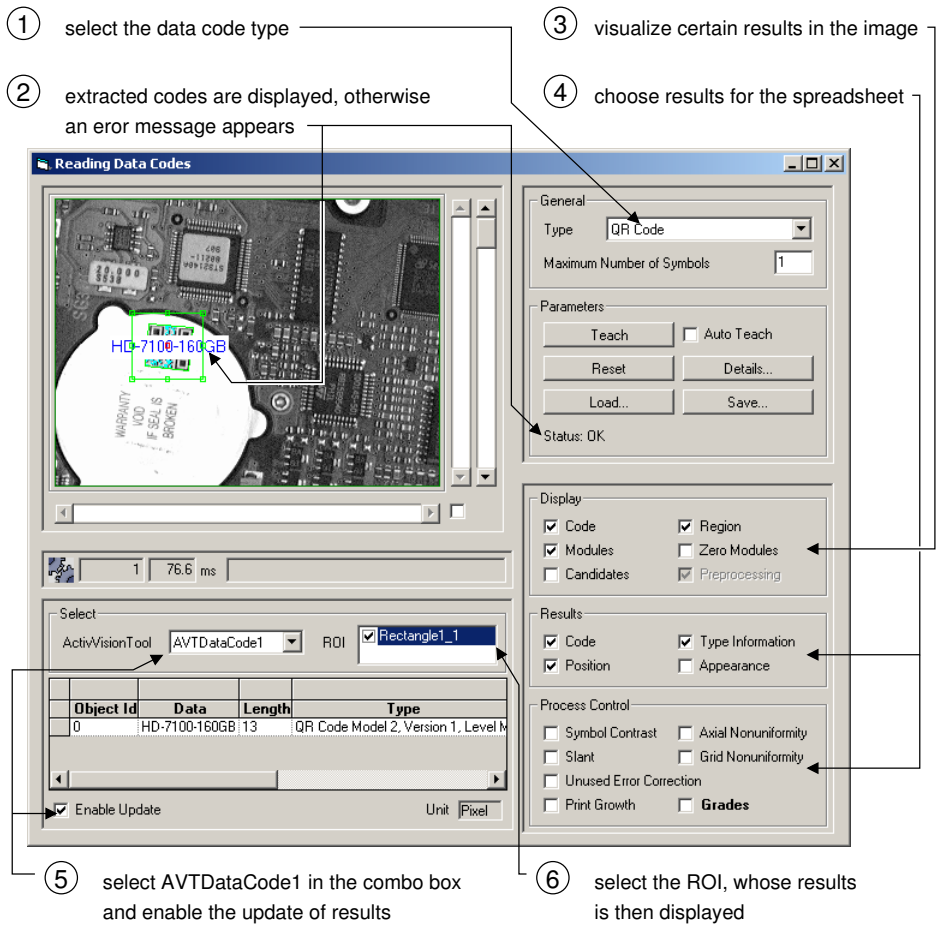


Figure 2.2: Reading data codes and selecting results.

5 To view the calculated features, select the tool whose results to display in the combo box `ActivVisionTool`, and enable the update of results in `AVTDataView`. If there is only one tool, it is selected automatically.

6 Automatically, a list of the ROIs of `AVTDataCode1` appears below. Select the ROIs whose results you want to examine by checking their box. Their results are then displayed in a table, the columns corresponding to the selected features.

2.3 Teaching Data Codes Using

The default values of the parameters of ActivDataCode are selected so that a broad range of data codes can be decoded without any user intervention. If a specific data code fails to fit within the boundaries of these default settings, you can ask ActivDataCode to adjust the parameters to fit. Furthermore, using a set of prototypical images, you can optimize the parameters to suit your application in the most efficient way. The more stable the appearance and quality of the data codes in your application the faster the processing.

Visual Basic Example

Preparation for the following example:

- ☐ If you worked on the previous example, you may continue using this project. Add `AVTViewFG` to the form by double-clicking . You may delete `AVTDataView` (if required, you can re-open it at run time by clicking into `AVTDataCode` with the right mouse button and selecting `Data View...`.

  Otherwise, open the project `teaching\datacode_teaching.vbp`.

- ☐ Execute the application (`Run` ▷ `Start` or via the corresponding button). Select the image sequence `datacode\ecc200\ecc200_teach.seq` in the combo box `Input File`. Remember to set the data code type back to `Data Matrix ECC 200` for this example.

The following steps are visualized in figure 2.3.

① Use the `Single` button to step through the sequence of images. Stop at the first image where the data code is not decoded.

② If a data code cannot be decoded, click `Detect and Teach`. ActivDataCode will try to adjust its internal parameters to read the displayed data code. Please note that the parameters will snap to the properties of that very data code the first time the button is clicked. As a result, data codes which could be read before may now require an additional training. The label of the button will change to `Teach`. Teaching subsequent data codes will widen the parameter range again. Thus, no teaching results will get lost.

③ If you have a large amount of sample images, you can instruct ActivDataCode to teach the data codes automatically by checking ☑ `Auto Teach`. In case you are using live images from a camera, auto teaching will slow down the application considerably if no data code is present in the image at all, e.g., while you are positioning a new object in the camera view. This is because ActivDataCode tries very hard to find at least one data code in each acquired image by widening the parameter set to the extremes. In applications like these, make sure to acquire triggered images in a setup where you know the image contains a data code.

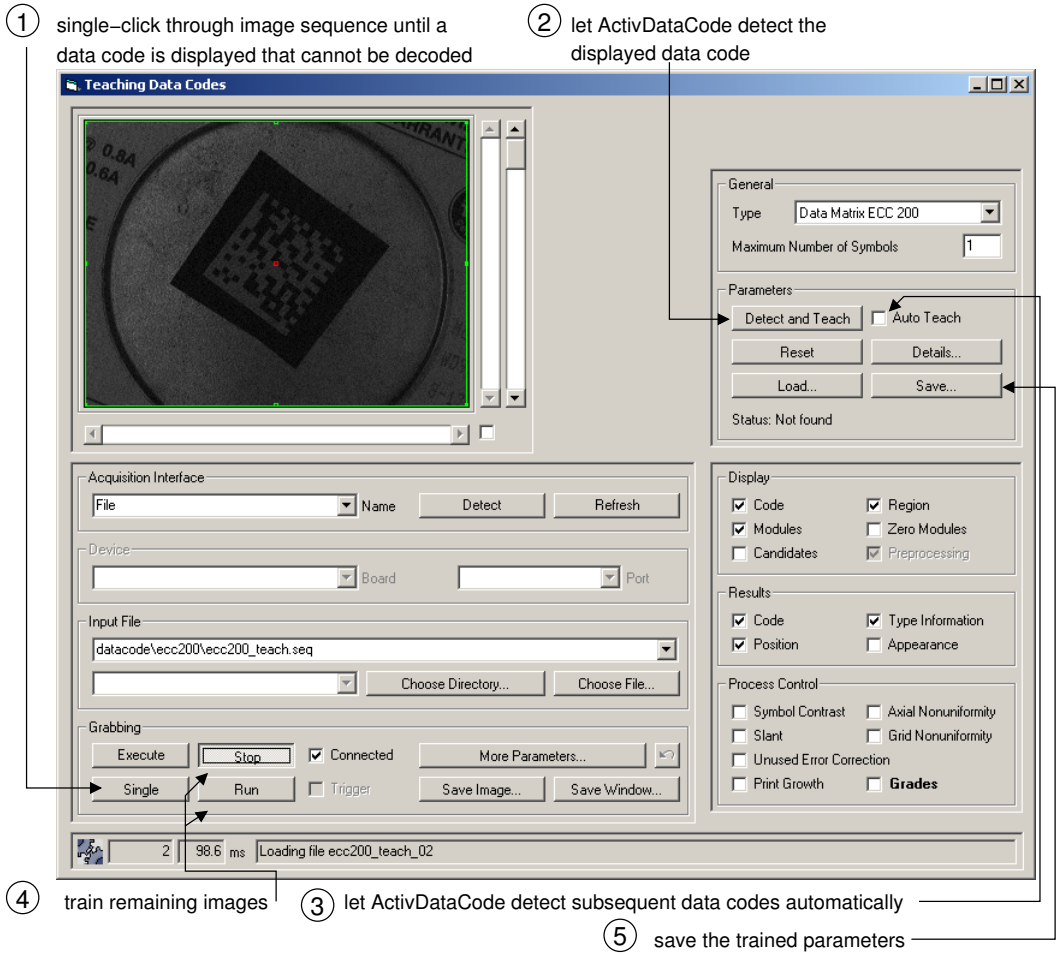


Figure 2.3: Teaching data codes.

4 Click the `Run` button to teach the remaining images of the sequence. If all images are trained, click the `Stop` button. You can track the file names of the sequence file by looking at the status bar.

5 The data code model is saved automatically when the application quits. You can also explicitly save the model of the trained data codes at any time. To do this, click the `Save` button and enter a file name. The default extension of these files is `.dmd` (data code model description).

2.4 Tuning Image Processing Using

Normally, there is no need to touch the internal parameters of ActivDataCode. If, however, auto-teaching fails simply because the properties of a data code lie outside of the search range, you can try to adjust the parameters manually. On the other hand, if the data code could be read but you want to know the detailed changes of a specific training step, you can also take a look at the parameter dialog. Reversely, you can explicitly set the parameters to certain known values and test a range of data codes for compliance. You can always return to the default settings at the click of a button.

Visual Basic Example

Preparation for the following example:

- ☐ If you worked on the previous example, you may continue using this project.
  Otherwise, open the project `tuning\datacode_tuning.vbp`.
- ☐ Execute the application (`Run` ▷ `Start` or via the corresponding button) and load the image `datacode\ecc200\ecc200_tune_04`. Open `AVTViewROI` by selecting `Region of Interest` in the popup menu and place an ROI over the data code. Click `Detect and Teach` in `AVTDataCode`. You will get a message saying that no data code could be detected in the image.

The following steps are visualized in figure 2.4

① Click the `Reset` button to set all the parameters to their default values, i.e., any training information will be lost.

② Select all check boxes in the `Display` frame of `AVTDataCodeSettings`. This will help you to see the changes to the decoding process while you are changing single parameter values. Specifically, make sure to check ☑ `Candidates` because this will highlight image areas that are considered to potentially contain data codes of the selected type.

③ Click the `Details` button to open the parameter dialog. Alternatively, you can add AVTDataCodeParameters ( ) to the form at design time. The default settings displayed in this dialog depend on the selected data code type. Some parameters are not available for all supported data codes. The corresponding parameters will be grayed out in the dialog.

④ Some parameter values can be changed by moving sliders. If both a minimum and a maximum value can be specified, two linked sliders are available. You can also specify the values explicitly by editing the text boxes. Using the arrow buttons, the values can be decremented or incremented. Other parameters can be specified by selecting from a combo box. When you change a parameter value, the current image is searched again

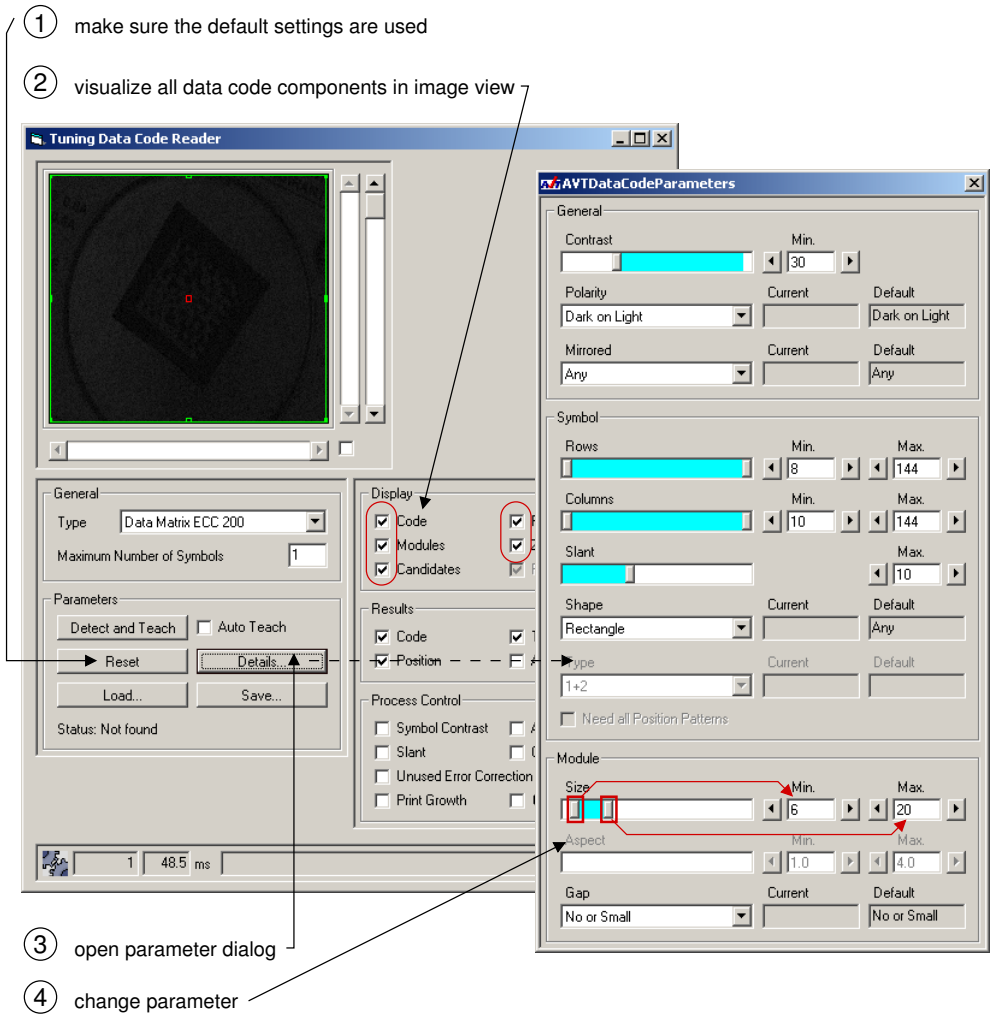


Figure 2.4: Tuning image processing parameters.

with the new settings.

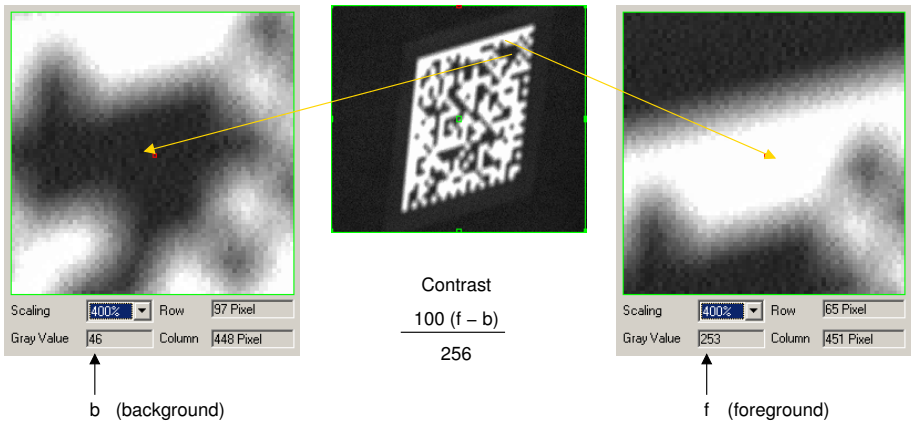
We continue with the example on the next double page.

(Tuning Image Processing, continued)

The following steps are visualized in figure 2.5 on page 17

⑤ `Contrast`: This parameter sets the minimum gray value difference between foreground and background modules. Decrease this value if the data code is not detected because of low contrast. If the data codes in your application are of high contrast, you can increase the value to speed up the application.

To determine a suitable value interactively, pick the gray values of sample foreground and background positions using the `Zoom` tool. To open it, click on the image with the right mouse button and select `Zoom` from the menu. The example below shows a data code with a high contrast.

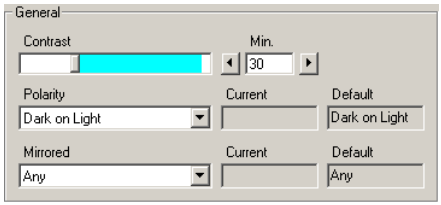


The image loaded in the example project has a very bad contrast. Thus, the `Contrast` value has to be decreased considerably. Watch the visualization of the candidates while pulling the slider to the lowest value.

⑥ `Polarity`: This parameter specifies if data codes appear positive (`Dark on Light`) or inverted (`Light on Dark`). Set to `Any` if both variants should be detected.

The polarity can be determined by looking at the finder pattern. In the example image, the polarity is `Light on Dark`. Change the parameter accordingly. The data code will now be decoded.

⑦ `Mirrored`: This parameter specifies whether data codes may appear mirrored. Set to `Any` if both variants occur or if you are uncertain about the appearance of the actual data code. It is sometimes hard to tell just by looking at the data code.



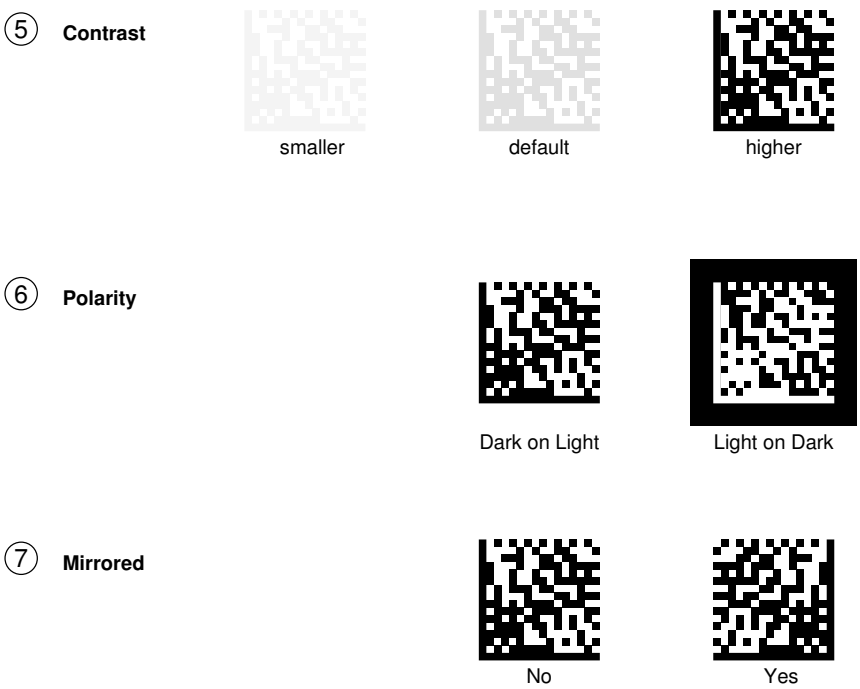


Figure 2.5: Tuning image processing parameters (cont.).

We continue with the example on the next double page.

(Tuning Image Processing, continued)

The following steps are visualized in figure 2.6 on page 19.

⑧ `Rows`: This parameter specifies the number of modules in vertical direction. Depending on the parameter `Shape`, it may be bound to `Columns`.

⑨ `Columns`: This parameter specifies the number of modules in horizontal direction. Depending on the parameter `Shape`, it may be bound to `Rows`.

⑩ `Slant` (ECC 200 only): Using this parameter, slanted data codes up to the specified degree can still be read by internally rectifying the image.

⑪ `Shape` (ECC 200 only): Data matrix codes are allowed in two different shapes: `Rectangle` and `Square`. The parameter refers to the shape of the data code itself, not the shape of the modules. Using this parameter, you can restrict the data code reader to a specific shape. Set to `Any` if both variants should be detected. Setting this parameter to `Square` will bind both `Rows` and `Columns` together so that moving one of the sliders will update the other one accordingly.

⑫ `Type` (QR Code only): There are two different models (variations) of QR Code data codes. This parameter specifies the model types that will be detected.

⑬ `All Position Patterns present` (QR Code only): QR Codes boast three position (finder) patterns. Use this parameter to control whether the data code reader needs to find all three patterns to read the data code or if two patterns suffice to start the decoding process.

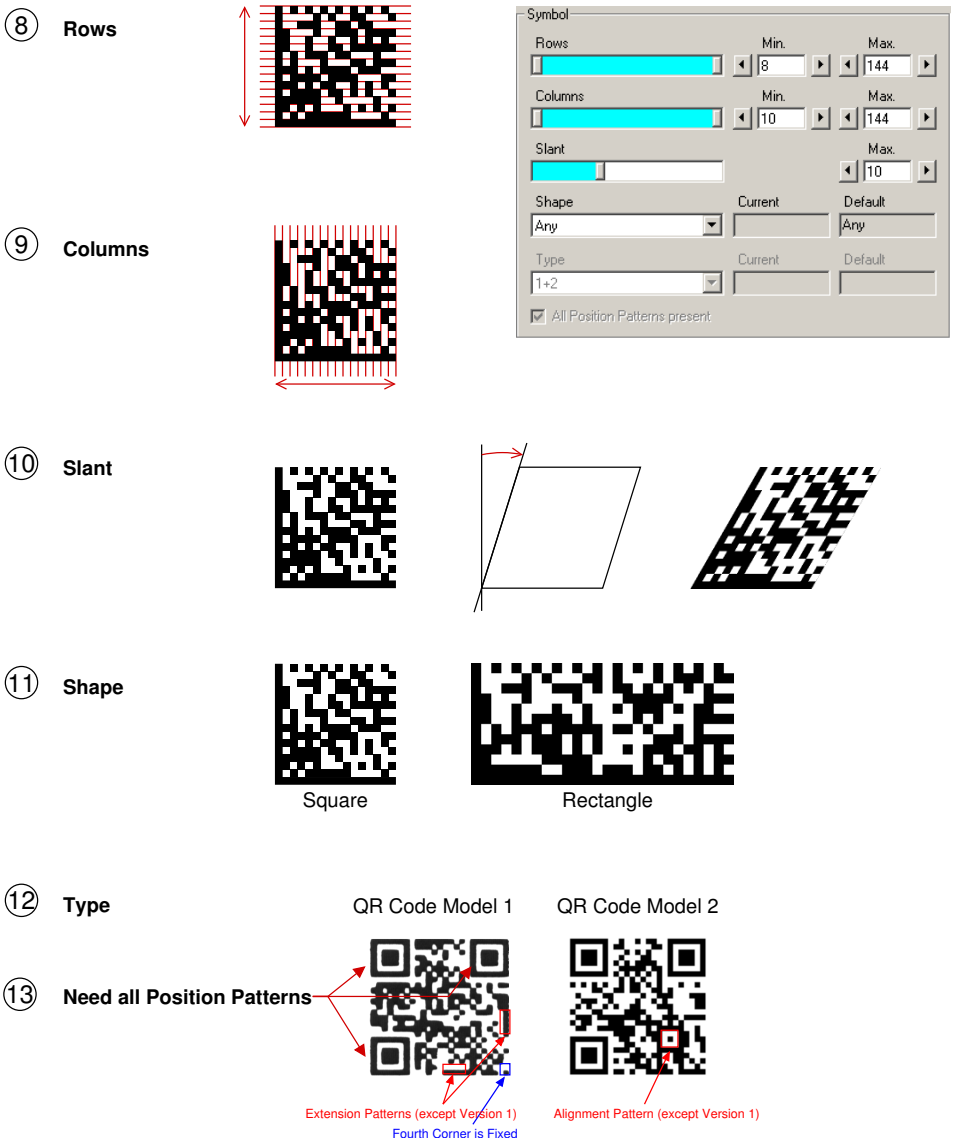


Figure 2.6: Tuning image processing parameters (cont.).

We continue with the example on the next double page.

(Tuning Image Processing, continued)

The following steps are visualized in figure 2.7 on page 21.

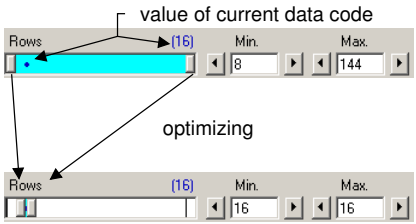
⑭ `Size`: This parameter specifies a valid range of pixel sizes for the modules. Data codes with module sizes outside of this range will not be detected.

⑮ `Aspect` (PDF417 only): In PDF417 data codes the height and the width of the modules may differ. Using this parameter, you can specify the valid range of aspect ratios.

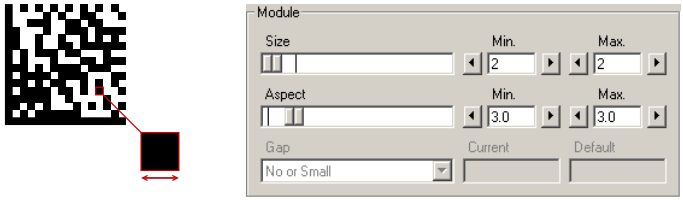
⑯ `Gap` (ECC 200 and QR Code only): Depending on the printing or embossing method, there may be gaps between the single modules of a data code. Using this parameter, you can indicate if gaps are allowed and to what degree. Set to `Any` if both very tight and very loose data codes should be detected.

Optimizing the Parameters of a Detected Data Code

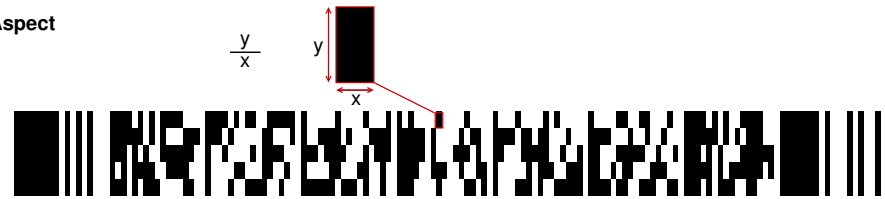
As soon as a data code is decoded, its actual parameter values are displayed in the parameter dialog. You can then optimize the parameters manually. If no teaching has been performed yet, you can also click the `Teach` button to snap the parameters to the current values. Optimizing the parameters will speed up your application.



⑭ **Size**



⑮ **Aspect**



⑯ **Gap**

Figure 2.7: Tuning image processing parameters (cont.).

2.5 Preprocessing Images Using

In some cases, the quality of the acquired images is so bad that a data code cannot be read. In other cases, the data code itself might be damaged, e.g., stamped, written upon, or distorted. If both teaching and manual parameter tweaking fail to produce any results, you may try to preprocess the image itself using various filters. Keep in mind to follow this approach only as a last resort.

In general, images of bad quality are the result of a poor image acquisition setup. Improper lighting causing reflections or uneven contrast, cameras oriented at an angle leading to various distortions, or even unsuitable camera lenses or positioning capturing images too small or too noisy all influence the reliability of ActivDataCode. Some of the defects caused by these weaknesses cannot be restored retrospectively.

Thus, it is usually much more effective to rectify the way images are acquired. Preprocessing is not a panacea, and it slows down image processing considerably.

Visual Basic Example

Preparation for the following example:

- ☐ If you worked on the previous example, you may continue using this project. Add `AVTDataCodePreprocessing` to the form by double-clicking .

  Otherwise, open the project `preprocessing\datacode_preprocessing.vbp`.

- ☐ Execute the application (`Run` ▷ `Start` or via the corresponding button) and load the image `datacode\ecc200\ecc200_preprocess.seq`. Open `AVTViewROI` by selecting `Region of Interest` in the popup menu and place an ROI over the data code.

The following steps are visualized in figure 2.8.

① Click `Detect and Teach` in `AVTDataCode`. ActivDataCode tries to detect the data code but fails. A corresponding message is displayed.

② Check ☑ `Auto Teach` to automatically adapt the parameters of ActivDataCode to the changes from the preprocessing filters.

③ Make sure all visualizations are enabled. This way, you can immediately see any detection improvements caused by preprocessing changes.

④ In `AVTDataCodePreprocessing`, check ☑ `Apply Preprocessing` to enable image preprocessing. This activates the preprocessing filters. The preprocessing is only applied to the ROIs.

⑤ Check ☑ `Display` to visualize the preprocessing changes in the image.

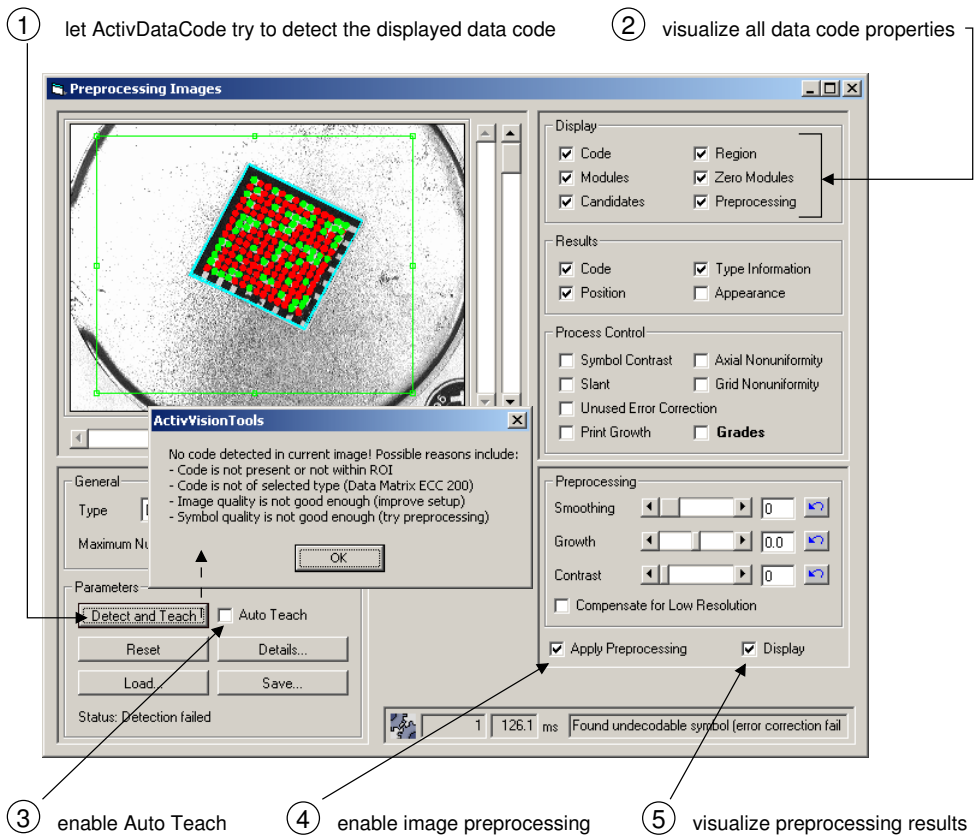


Figure 2.8: Preprocessing the image.

We continue with the example on the next double page.

(Preprocessing Image Processing, continued)

The following steps are visualized in figure 2.9

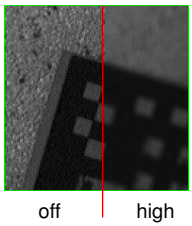
⑥ `Smoothing`: This filter is particularly useful for noisy images. Besides, it may improve data code detection if the finder pattern of the data code is disturbed, e.g., by lines in the background or foreground.

⑦ `Growth`: If negative, this filter enlarges bright image areas. If positive, it enlarges dark image areas. It is most useful for data codes of bad print quality. If too much ink is used in the printing process, the ink tends to bleed in the surrounding area causing a so-called print growth. If too few ink is used, the modules may become frayed or full of holes. By adjusting the `Growth` value accordingly, these deficiencies can be compensated.

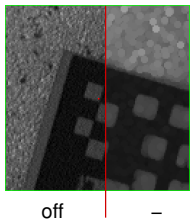
⑧ `Contrast`: This filter enhances the contrast of the image. It may improve data code detection in low contrast images.

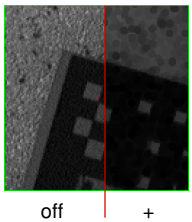
⑨ ☑ `Compensate for Low Resolution`: The data code expects the modules to have a specific minimum size. Enabling this filter will improve detection of data codes with very small module sizes.

⑥ **Smoothing**

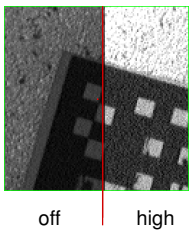


⑦ **Growth**





⑧ **Contrast**



⑨

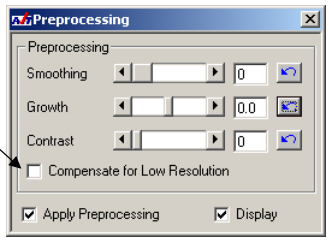


Figure 2.9: Applying the preprocessing filters.

Chapter 3

Combining ActivDataCode with other ActivVisionTools

While the previous chapter explained how to read data codes, this chapter focuses on how to further evaluate and output the results using other ActivVisionTools. How to access results and evaluations via the programming interface is described in chapter 4 on page 35.

In the corresponding Visual Basic projects, the task is to read and evaluate a sequence of data codes.

3.1 Converting Results to Other Units **28**
3.2 Evaluating Results **30**
3.3 Output of Results **32**

3.1 Converting Results to Other Units Using

Up to now, the position of a data code was measured in image coordinates, i.e., pixels. Using `AVTViewCalibration`, you can convert this information into other units. Note that for a more accurate calibration you should employ ActivGeoCalib.

The main idea behind `AVTViewCalibration` is that the user draws a line in the image and tells ActivVisionTools the length of this line in a certain unit. From this information, `AVTViewCalibration` calculates the size of a pixel (i.e., its height as square pixels are assumed) in this unit, which in its turn can be used to convert measurements from pixels into the new unit. Note that this conversion only works if the observed objects lie in the same plane, i.e., at the same distance from the camera, as the line whose length was specified.

Visual Basic Example

Preparation for the following example:

- ☐ If you worked on the example in the previous chapter, you may continue using this project. At design time, add `AVTViewROI`, `AVTViewCalibration`, and `AVTDataView` to the form by double-clicking , , and with the left mouse button.

  Otherwise, open the project `units\datacode_units.vbp`.
- ☐ Execute the application and open `AVTViewFG` by clicking into `AVTView` with the right mouse button and selecting `Image Acquisition`. Load the image sequence `datacode\ecc200\ecc200_teach.seq`.

The following steps are visualized in figure 3.1 (not shown: `AVTDataCode`).

1. You create the line of known length using `AVTViewROI`. First, select `AVTViewCalibration1` in the combo box `ActivVisionTool`.
2. To start creating the line, click .
3. To draw the line, move the mouse in the image while keeping the left mouse button pressed.
4. You can edit the line by dragging its pick points. For fine positioning, zoom the image and move the displayed part using the scrollbars to the right and below the image.
5. Select a unit in the combo box `Unit` of`AVTViewCalibration`.

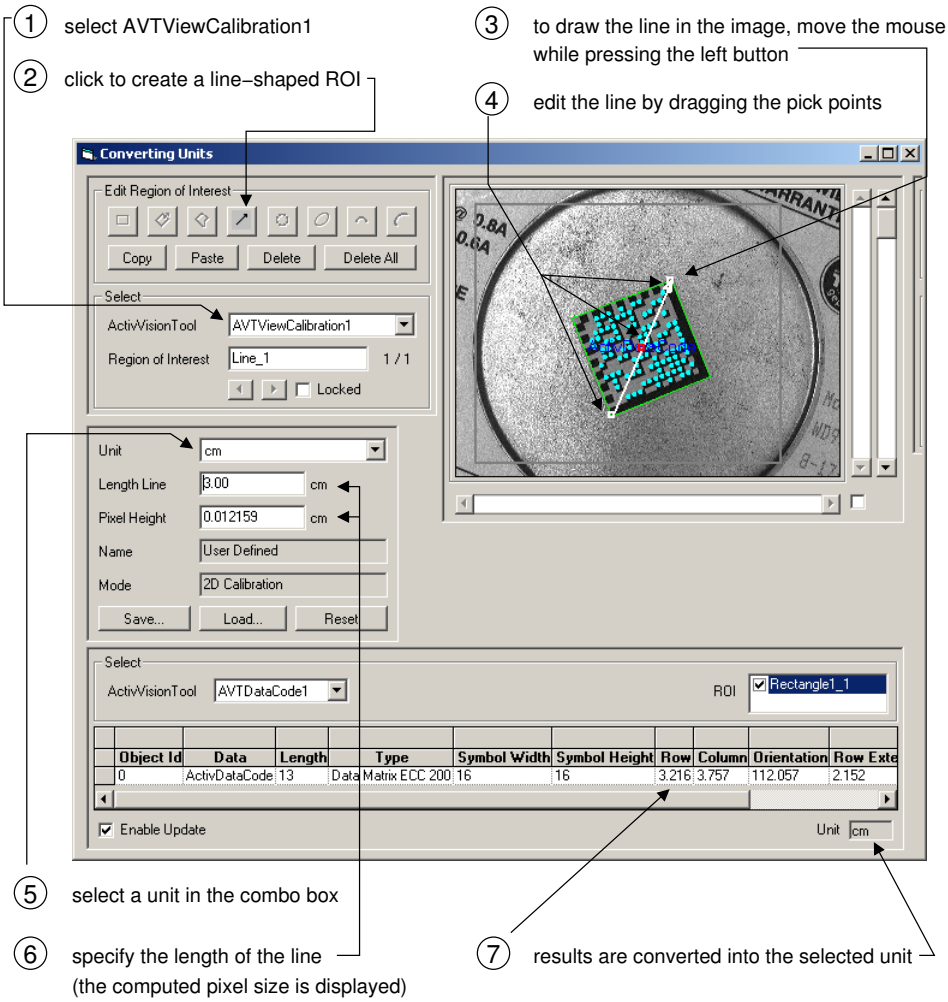


Figure 3.1: Converting positions into other units.

(6) Specify the length of your line (in the example: $3.1cm$) in the text box `Length Line` and press `Enter`. `AVTViewCalibration` now calculates the height of a pixel in the selected unit and displays it in the text box `Pixel Height`.

(7) Automatically, the data code position is converted into the selected unit.

3.2 Evaluating Results Using

In the former examples, you have employed ActivVisionTools to extract and display data codes and additional features. Using ActivDecision, you can evaluate these results by formulating *conditions* the results have to meet in order to be "okay". For a detailed description of ActivDecision please consult the User's Manual for ActivDecision.

Visual Basic Example

Preparation for the following example:

- ☐ If you worked on the previous example, you may continue using this project. At design time, add `AVTDecision` to the form by double-clicking with the left mouse button; delete `AVTDataView`, `AVTViewCalibration`, and `AVTViewROI`.

  Otherwise, open the project `decisions\datacode_decisions.vbp`.

- ☐ Execute the application and load the image sequence `datacode\qrcode\qr_hd.seq`.

The following steps are visualized in figure 3.2 (not shown: `AVTView` and `AVTDataCode`).

① The main functionality of ActivDecision is presented by its *support tools*, which can be opened via clicking on `AVTDecision` with the right mouse button. The *master tool* displays the overall evaluation of the application.

② To view the current feature and evaluation results check ☑ `Enable Update` in `AVTDecisionViewResults`.

③ ActivDecision lets you compare the value of an individual object, ROI, or tool feature with two boundary values, a minimum and a maximum value. In the image sequence, two different data codes appear, `HD-7100-080GB` and `HD-7100-160GB`; only the latter is to be evaluated as "okay". In the columns `Min` and `Max`, change the minimum and maximum values for the feature `Data` accordingly. Now, select a condition that the result has to meet in the column `Operation`. In our example, the `Data` has to be equal to the `Max` value. If you select `None`, the result is not evaluated.

④ Those features which meet their condition appear in green, the others in red. If at least one feature is "not okay", the whole object, ROI, or tool is evaluated as "not okay" as well. Analogously, the overall evaluation of the application, which is visualized by `AVTDecision`, depends on the tool evaluations.

Figure 3.2 shows suitable conditions for the example task. Step through the image sequence by clicking `Single` in `AVTViewFG` and examine the evaluations. Experiment by formulating additional conditions, e.g., regarding the position or orientation of the data codes.

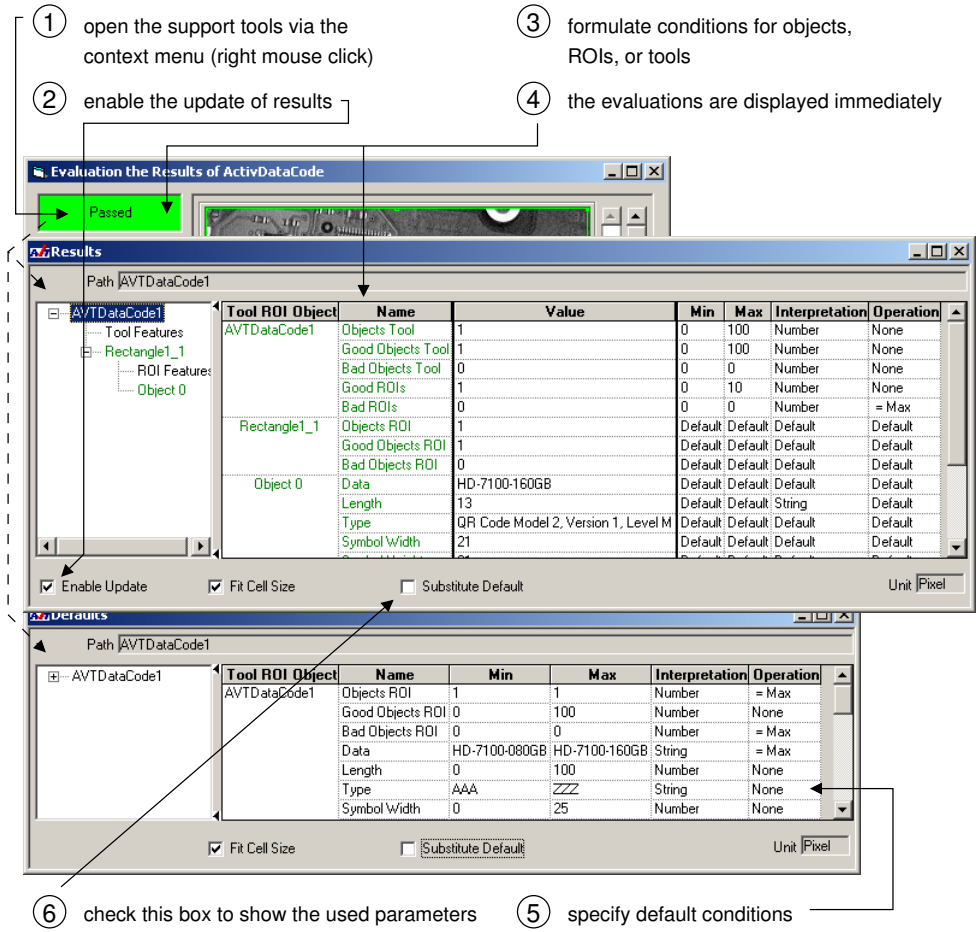

1 open the support tools via the context menu (right mouse click)
2 enable the update of results
3 formulate conditions for objects, ROIs, or tools
4 the evaluations are displayed immediately
Evaluation the Results of ActivDataCode
Passed
Results
Path AVTDataCode1
AVTDataCode1
Tool Features
Rectangle1_1
ROI Features
Object 0
Tool ROI Object | Name | Value | Min | Max | Interpretation | Operation
AVTDataCode1 | Objects Tool | 1 | 0 | 100 | Number | None
Good Objects Tool | 1 | 0 | 100 | Number | None
Bad Objects Tool | 0 | 0 | 0 | Number | None
Good ROIs | 1 | 0 | 10 | Number | None
Bad ROIs | 0 | 0 | 0 | Number | = Max
Rectangle1_1 | Objects ROI | 1 | Default | Default | Default | Default
Good Objects ROI | 1 | Default | Default | Default | Default
Bad Objects ROI | 0 | Default | Default | Default | Default
Object 0 | Data | HD-7100-160GB | Default | Default | Default | Default
Length | 13 | Default | Default | String | Default
Type | QR Code Model 2, Version 1, Level M | Default | Default | Default | Default
Symbol Width | 21 | Default | Default | Default | Default
Enable Update
Fit Cell Size
Substitute Default
Unit Pixel
Defaults
Path AVTDataCode1
AVTDataCode1
Tool ROI Object | Name | Min | Max | Interpretation | Operation
AVTDataCode1 | Objects ROI | 1 | 1 | Number | = Max
Good Objects ROI | 0 | 100 | Number | None
Bad Objects ROI | 0 | 0 | Number | = Max
Data | HD-7100-080GB | HD-7100-160GB | String | = Max
Length | 0 | 100 | Number | None
Type | AAA | ZZZ | String | None
Symbol Width | 0 | 25 | Number | None
Fit Cell Size
Substitute Default
Unit Pixel
6 check this box to show the used parameters
5 specify default conditions

Figure 3.2: Formulating conditions to evaluate results.

(5) If many similar objects are extracted that all should meet the same conditions, you can specify default conditions using `AVTDecisionViewDefaults`. Defaults can be set per tool or per ROI; ROI defaults override tool defaults, and individual conditions override defaults.

(6) If you check ☑ `Substitute Default`, the entries marked `Default` are substituted by their actual content.

3.3 Output of Results Using

Using ActivFile, you can write the results and the evaluations to a log file. How to access results via the programming interface is described in section 4.3 on page 40, how to output them via a serial interface or a digital I/O board in the User's Manual for ActivSerial and the User's Manual for ActivDigitalIO, respectively.

Visual Basic Example

Preparation for the following example:

- ☐ If you worked on the previous example, you may continue using this project. At design time, add `AVTOutputFile` by double-clicking .

  Otherwise, open the project `output\datacode_output.vbp`.

- ☐ Execute the application and load the image sequence `datacode\ecc200\ecc200_capsules.seq`.

The following steps are visualized in figure 3.3 (not shown: `AVTView`, `AVTDataCode`, `AVTDecision`).

① By clicking on `Select`, you can open a file selector box to choose a file name for the log file, which will then appear in the text field beside the button. By pressing `Clear File`, you can clear the content of the selected file.

② By checking ☑ `Enable Writing` you enable the writing mode.

③ You can open the ActivFile's two dialogs `DialogFileOptions` and `DialogOutputDataSelect` by clicking `File Options` and `Data Selection`, respectively.

④ In `DialogFileOptions`, you can choose between two file formats: Standard text files (suffix `.txt`) and the so-called *comma-separated values* (suffix `.csv`), which can be used as an input to Microsoft Excel. Furthermore, you can select a delimiter.

⑤ In the same dialog you can limit the size of the log file in form of the number of *cycles* that are to be recorded. A cycle corresponds to one processing cycle from image input to the evaluation and output of results. If you use this option, ActivFile creates two log files and switches between them, thus assuring that you can always access (at least) the results of the last N cycles, N being the specified number of cycles.

⑥ By pressing `Estimate`, you can let ActivFile estimate the size of one cycle. Note that you must first select the output data in order to get meaningful results!

⑦ In the left part of `DialogOutputDataSelect`, you can navigate through the result hierarchy similarly to ActivDecision.

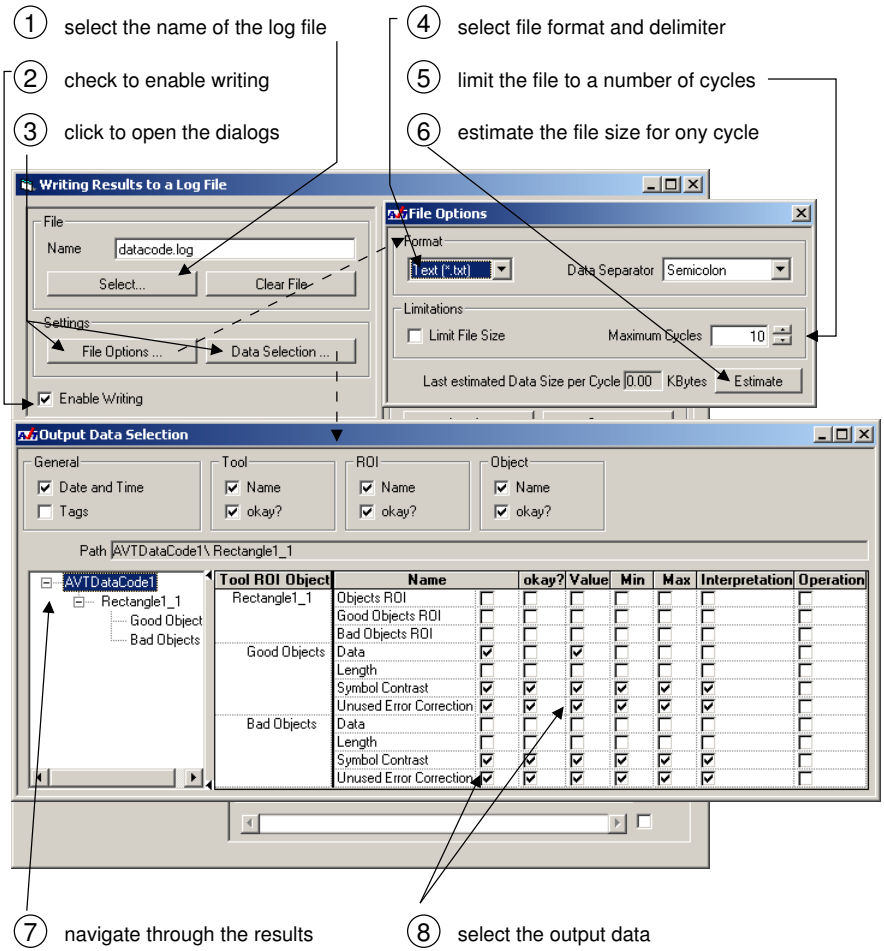


Figure 3.3: Customizing log files.

(8) In the right part of `DialogOutputDataSelect`, choose the output data by checking the corresponding boxes. You may output different items depending on the evaluation of an object. By clicking on the column labels with the right mouse button you can check or uncheck all boxes in the column; similarly, you can check or uncheck whole rows or all rows of a certain tool.

If you now step through the image sequence by clicking `Single` in `AVTViewFG`, the log file is created. Figure 3.4 shows part of an example log file.

```
12/06/05;16:21:21
  AVTDataCode1;yes
    Rectangle1_1;yes
      0;yes
          Data;cla502976
          Symbol Contrast;yes;0.200507;0.200000;1.000000;Number
          Unused Error Correction;yes;1.000000;0.200000;1.000000;Number
12/06/05;16:21:22
  AVTDataCode1;no
    Rectangle1_1;no
      0;no
          Symbol Contrast;no;0.171800;0.200000;1.000000;Number
          Unused Error Correction;no;0.166667;0.200000;1.000000;Number
12/06/05;16:21:22
  AVTDataCode1;no
    Rectangle1_1;no
      0;no
          Symbol Contrast;no;0.195253;0.200000;1.000000;Number
          Unused Error Correction;yes;1.000000;0.200000;1.000000;Number
12/06/05;16:21:22
  AVTDataCode1;yes
    Rectangle1_1;yes
      0;yes
          Data;tre502971
          Symbol Contrast;yes;0.228574;0.200000;1.000000;Number
          Unused Error Correction;yes;0.333333;0.200000;1.000000;Number
12/06/05;16:21:23
  AVTDataCode1;yes
    Rectangle1_1;yes
      0;yes
          Data;tre502973
          Symbol Contrast;yes;0.213203;0.200000;1.000000;Number
          Unused Error Correction;yes;0.833333;0.200000;1.000000;Number
12/06/05;16:21:23
  AVTDataCode1;yes
    Rectangle1_1;yes
      0;yes
          Data;tre502974
          Symbol Contrast;yes;0.238092;0.200000;1.000000;Number
          Unused Error Correction;yes;0.500000;0.200000;1.000000;Number
```

Figure 3.4: Part of an example log file.

Chapter 4

Tips & Tricks

This chapter contains additional information that facilitates working with ActivDataCode, e.g., how to modify the graphical display of results and how to customize the appearance of an ActivDataCode application in the two execution modes. Furthermore, it shows how to access data code extraction and evaluation results directly via the programming interface of the ActivVisionTools.

4.1 Adapting the Display of Results **36**
4.2 Configuring the Two Execution Modes **38**
4.3 Accessing Results Via the Programming Interface **40**
4.3.1 Results of Data Code Extraction 41
4.3.2 Evaluation Results 46

4.1 Adapting the Display of Results Using

You can adapt the way results and ROIs are displayed using `AVTViewDisplayModes`, which is a *support tool* of ActivView.

Visual Basic Example

Preparation for the following example:

- ☐ If you worked on the example in the previous chapter, you may continue using this project.

  Otherwise, open the project `display\datacode_display.vbp` and execute it (`Run` ▷ `Start` or via the corresponding button).

- ☐ Load the image sequence `datacode\qrcode\qr_hd.seq` and create some additional ROIs; `AVTViewFG` and `AVTViewROI` can be opened at run time via a right mouse button click on `AVTView`.

The following steps are visualized in figure 4.1. Experiment by choosing different settings for the display parameters and watching the result.

1. Open `AVTViewDisplayModes` by clicking on `AVTView` with the right mouse button and selecting `Display Modes` in the popup menu.
2. Change the color of the selected pick point. Select another pick point by clicking into its vicinity.
3. Change the color of the currently selected ROI. Select another ROI by clicking into its vicinity. Change the color of the other, not selected ROIs of the currently selected tool. Change the color of the ROIs of the other, not selected tools. Select another tool in the combo box `ActivVisionTool` of `AVTViewROI` (if this box contains more than one item). If you use ActivDecision to evaluate results, it can mark ROIs evaluated as “not okay” in a special color.
4. Change the LUT (look-up table) that is used to display the image.
5. Change the line width of the ROIs or of the modules (or the region margin, see below).
6. Change the color of the modules and candidates (in the text box `Group I`) or the color of the zero modules and the region (text box `Group II`).
7. ActivDecision uses a separate color to mark objects evaluated as “not okay”. Besides this, a further color is used for highlighting objects if you click on them in ActivDataView or in the tree of ActivDecision. To test the effect, open ActivDataView by clicking on `AVTDataCode` with the right mouse button and selecting `Data View...` in the ap-

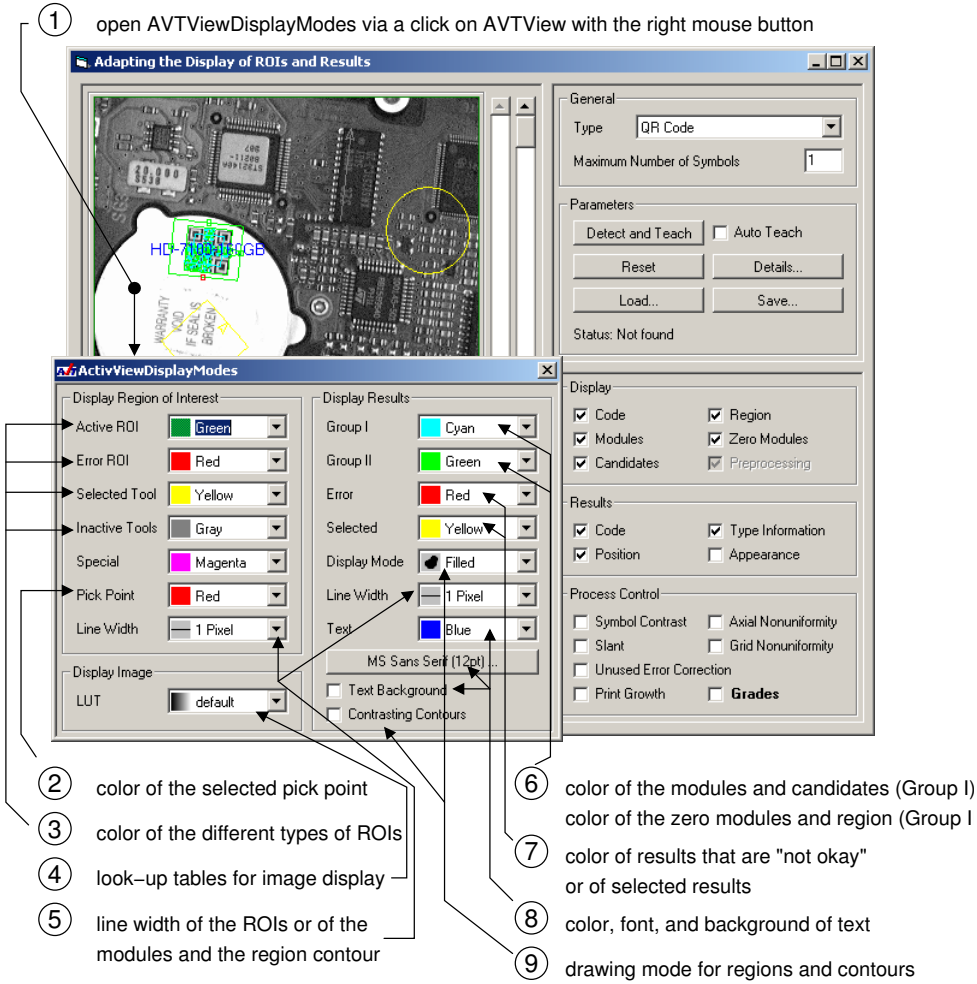


Figure 4.1: Adapting the display of ROIs and results.

pearing context menu; then, click on a object, which is automatically highlighted in `AVTView`.

(8) Change the color and the font of the text and whether it is displayed on a contrasting background.

(9) Change the way modules are displayed (filled or margin) and whether contours and text are framed with a contrasting color to make them more visible against busy backgrounds.

4.2 Configuring the Two Execution Modes Via and

In an ActivVisionTools application you can switch between two execution modes: the *configuration mode* and the *application mode*. The former should be used to setup and configure an application, the latter to run it. ActivView's *support tools* `AVTViewExecute` and `AVTViewConfigExec` allow you to switch between the two modes and to customize the behavior of an ActivVisionTools application in the two execution modes, e.g., display live images only in the *configuration mode* to setup your application, but then switch it off in the *application mode* to speed up the application. A third sub-tool, `AVTViewExecuteSimple`, provides a single button to start/stop the application. In this section we also describe `AVTViewStatus` in more detail.

Visual Basic Example

Preparation for the following example:

- ☐ If you worked on the example in the previous chapter, you may continue using this project. At design time, add `AVTViewExecuteSimple` and `AVTViewStatus` to the form by double-clicking the icons and with the left mouse button.

  Otherwise, open the project `usermodes\datacode_usermodes.vbp`.

- ☐ Execute the application and load the sequence `datacode\qrcode\qr_hd.seq`.

The following steps are visualized in figure 4.2 (not shown: `AVTDataCode`).

① Open `AVTViewExecute` and `AVTViewConfigExec` by clicking on `AVTView` with the right mouse button and selecting `Execution` and `Execution Parameters`.

② Switch between the two execution modes via `AVTViewExecute`'s combo box `Mode`.

③ To execute one cycle, press `Single`. With the other two buttons you can let the application run continuously and stop it again. By default, `AVTViewExecuteSimple` starts and stops an application; how to change its behavior to a single-step button is described in the User's Manual for ActivView, section 3.4 on page 34.

④ For each of the two execution modes, you can choose what is to be displayed by checking the corresponding boxes in `AVTViewConfigExec`. Furthermore, you can specify if images can be dragged to the image window and whether ROIs can be modified in the two modes.

⑤ In `AVTViewStatus`, an icon indicates the current execution mode of the application. In the mode , the application does not perform any processing and waits for your interaction. If you start the continuous mode, the cogwheels rotate; any interaction on your part is stored in the event queue and processed after the current cycle is finished.If

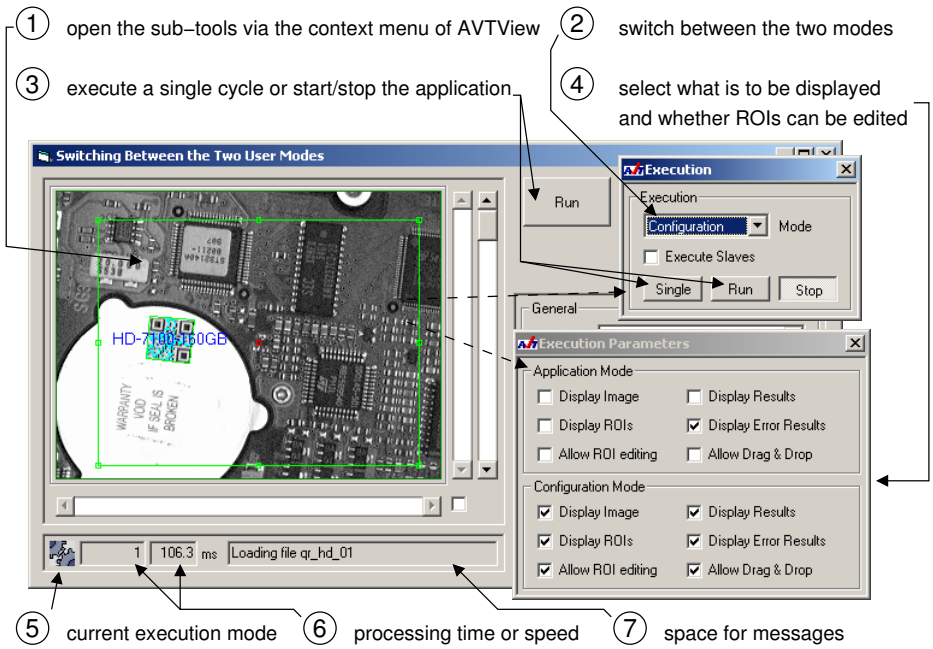


Figure 4.2: Customizing and switching between the two execution modes.

the cursor gets “busy”, ActivVisionTools has started a particularly time-consuming operation, e.g., connecting to an image acquisition device. Any interaction on your part is then deferred to the end of this operation.

(6) `AVTViewStatus` also shows the number of processed cycles and the time needed for the last processing cycle.

(7) `AVTViewStatus` display two types of messages: Informative messages describe, e.g., what the application is doing while it is “busy”, while error messages indicate errors that prevent the application from working correctly, e.g., the failure to detect a data code automatically. Note that the failure to find a data code ranks as an information and not as an error, i.e., the application is not interrupted. You can use ActivDecision to mark such cases as “not okay”.

If `AVTViewStatus` is not added to an application, error messages are displayed in popup dialogs.

More information about `AVTViewStatus`, e.g., how to modify its appearance, can be found in the User’s Manual for ActivView, section 3.3 on page 32.

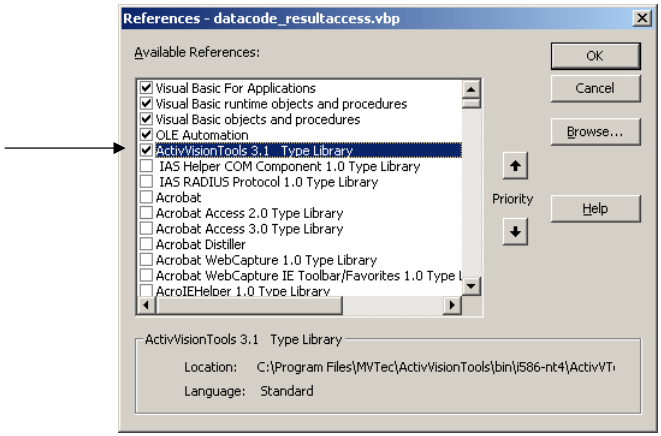
4.3 Accessing Results Via the Programming Interface

The previous chapters and sections showed how to use ActivVisionTools interactively, i.e., via the graphical user interfaces presented by the underlying ActiveX controls. In this mode, you can develop the image processing part of your machine vision application rapidly and easily, without any programming. However, there is more to ActivVisionTools than the graphical user interfaces: Because ActivVisionTools comes as a set of ActiveX controls, it provides you with an open programming interface, thereby offering full flexibility.

In this section, we show how to access the results of the data code extraction and of their evaluation via the programming interface. With this, you can, e.g., realize an application-specific graphical user interface, perform additional processing on the results, or send results to a special output device. Detailed information about the programming interface can be found in the **Reference Manual**.

As in the previous sections, the examples stem from Visual Basic 6.0; if the (ActivVisionTools-specific) code differs in Visual Basic .NET, the corresponding lines are also shown (for the first appearance only). For other .NET languages or C++, please refer to the Advanced User's Guide for ActivVisionTools, section 1.2.3 on page 5 and section 1.3.4 on page 28, respectively. Please note that we assume that readers of this part have at least a basic knowledge of Visual Basic.

To work with the programming interface, in Visual Basic 6.0 you must first **add the ActivVisionTools type library to the project's references** by checking the box labeled `ActivVisionTools Type Library` in the Visual Basic menu dialog `Project` ▷ `References`. In Visual Basic .NET, the reference is added automatically.



4.3.1 Accessing the Results of Data Code Extraction

The principal idea behind accessing the results of an ActivVisionTool is quite simple: When a tool has finished its execution, it raises an event called `Finish`, sending its results as a parameter. If you want to access the results, all you have to do, therefore, is to create a corresponding event procedure which handles the event.

Within the Visual Basic environment, you can create event procedures very easily as shown in figure 4.3: In the header of the form's code window corresponding to a form there are two combo boxes. Select the instance of `AVTDataCode` (by default called `AVTDataCode1`) in the left combo box. The right combo box then lists all events available for this object; when you select `Finish`, the event procedure is created automatically. Within this procedure, the results of the data code extraction are now accessible via the object variable `atToolResults`.

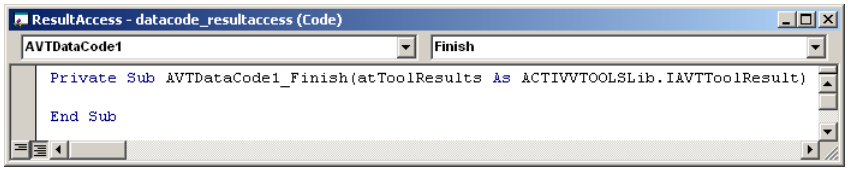


Figure 4.3: Creating a procedure to handle the event `Finish` .

The variable `atToolResults` contains the result data for all ROIs of your instance of `AVTDataCode`. The current number of ROIs can be queried via

```
Dim iNumROIs As Integer

iNumROIs = atToolResults.ROINum
```

In Visual Basic .NET , the event handler has a different signature:

```
Private Sub AxAVTDataCode1_Finish(ByVal sender As Object, _
                                  ByVal e As _
                                    AxActivVTools.__AVTDataCode_FinishEvent) _
                                  Handles AxAVTDataCode1.Finish
```

A first difference is that tool names start with the prefix `Ax`, i.e., `AVTDataCode` becomes `AxAVTDataCode` . The main difference, however, is that the tool results are not directly passed: instead, they are encapsulated in the parameter `e`. From there, they can be extracted with the following lines:

```
Dim atToolResults As AVTToolResult
atToolResults = e.atToolResults
```

To use classes like `ACTIVVTOOLSLib.AVTToolResult` without the namespace `ACTIVVTOOL-`

SLib as in the code above, you must import this namespace by inserting the following line at the very beginning of the code (more information about importing namespaces can be found in the Advanced User's Guide for ActivVisionTools in section 1.2.4.5 on page 12):

```
Imports ACTIVVTOOLSLib
```

The results of a certain ROI can be accessed by specifying its name in a call to the method ROIResult, or by specifying its index in a call to the method ROIResults. The following code uses the latter method to access the first ROI of AVTDataCode1:

```
Dim atROIResult As AVTROIResult

Set atROIResult = atToolResults.ROIResults(0)
```

Now, we can, e.g., query the number of objects extracted in the ROI via

```
Dim iNumObjects As Integer

iNumObjects = atROIResult.ObjectNum
```

Actual results for an object, i.e., the extracted code or the calculated position can be accessed by specifying the feature of interest and the ID of the object in a call to the method ObjectValue of ACTIVVTOOLSLib.AVTROIResult. The feature handles are available as methods of the corresponding tool, e.g., AVTDataCode.FeatureHandleCode being the handle for the extracted code.

The following code fragment uses another method of ACTIVVTOOLSLib.AVTROIResult, ObjectValues, which returns the values of all objects for the specified feature in an array, to calculate the mean unused error correction of the data codes:

```
Dim handleUEC As Integer, i As Integer
Dim vUECArray As Variant
Dim dSumUEC As Double, dMeanUEC As Double

handleUEC = AVTDataCode1.FeatureHandleUnusedErrorCorrection
vUECArray = atROIResult.ObjectValues(handleUEC)
dSumUEC = 0
For i = 0 To iNumObjects - 1
  dSumUEC = dSumUEC + vUECArray(i)
Next
dMeanUEC = dSumUEC / iNumObjects
```

As already noted, **in Visual Basic .NET** tool names are prefixed with Ax, thus the feature handle is accessed as follows:

```
handleUEC = AxAVTDataCode1.FeatureHandleUnusedErrorCorrection
```

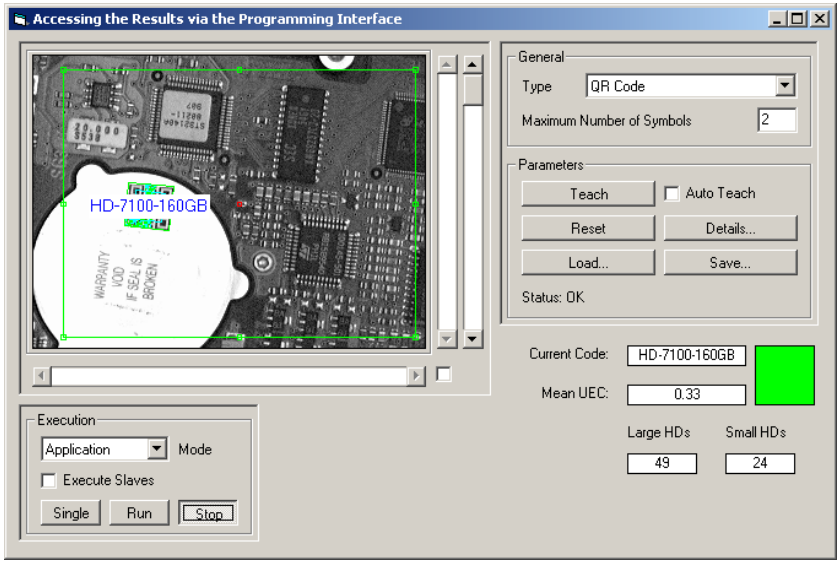


Figure 4.4: Accessing and displaying the results of data code extraction.

The ActivVisionTools distribution includes the example Visual Basic project `resultaccess\datacode_resultaccess.vbp`, which uses the methods described above to extend the application for reading a sequence of data codes introduced in the previous chapter. The task is to display the extracted code, which identifies hard disks of different sizes. Depending on the hard disk size, counters for large and small hard disks are updated. To control the overall quality of the data codes, the mean value of the `Grade UEC` (unused error correction) feature is also calculated. The higher the displayed value, the better the overall quality of the data codes (see figure 4.4). The example project is already configured, just start it and click the button `Run` in `AVTViewExecute`.

Besides accessing the results of data code extraction, the project code contains additional functionality which is explained briefly in the following. Note that the code is only shown for Visual Basic 6.0; a Visual Basic .NET application with result access can be found in the directory `examples\dotnet\vb\datacode_results`.

First of all, the extracted code and the unused error correction is only to evaluated if exactly one object has been extracted:

```
If iNumObjects = 1 Then
  sCode = atROIResult.ObjectValue(handleCode, 0)
  LabelCode.Caption = sCode
  dUEC = atROIResult.ObjectValue(handleUEC, 0)

Else
  LabelCode.Caption = "<multiple>"
  Call SetAlarm
End If
```

If not exactly one object is extracted, the function `SetAlarm` stops the application by setting `AVTView`'s property `RunState` to `'False'` and switches the color of the status element below the image to red. The function `ClearAlarm` resets the color to green. To test this behavior step through the images sequence to an image containing two data codes.

```
Private bIsError As Boolean

Private Function SetAlarm()
  AVTView1.RunState = False
  Light.BackColor = vbRed
  bIsError = True
End Function

Private Function ClearAlarm()
  Light.BackColor = vbGreen
  bIsError = False
End Function
```

When calculating the mean unused error correction, one has to keep in mind that `AVTDataCode` is executed not only when the next image is grabbed but also whenever you modify its ROI (s) or parameters. To distinguish the two cases, an event raised by `AVTView` at the start of each execution cycle can be used to set a flag called `bIsNewCycle`:

```
Private bIsNewCycle As Boolean

Private Sub AVTView1_CycleStart()
  bIsNewCycle = True
End Sub
```

Before calculating the mean values within the handler for `AVTDataCode`'s event `Finish`, this variable is checked (and immediately reset).

```
If bIsNewCycle = True Then
  iNumGoodCycles = iNumGoodCycles + 1
  bIsNewCycle = False
  dSumUEC = dSumUEC + dUEC
  dMeanUEC = dSumUEC / iNumGoodCycles
  LabelUEC.Caption = Format(dMeanUEC, "Fixed")
End If
```

You can test this behavior by changing parameters in `AVTDataCodeParameters`: The code is updated, while the mean value of the unused error correction remains constant.

When using the programming interface of ActivVisionTools, you leave the safe world of the graphical user interfaces where all input is checked for validity automatically. In contrast, if you try to access a non-existent object or result via the programming interface, a run-time error is caused which terminates your application! To avoid this, you can use the Visual Basic error handling mechanisms, i.e., set up an error handler which examines any occurring error and reacts in a suitable way. In the example project, if an error is caused by the result access, a dialog with the error description pops up and the function `SetAlarm` is called. To view the effect of the error handler, uncheck ☑ `Unused Error Correction` in `AVTDataCodeSettings` so that the unused error correction is not calculated.

```
Private Sub AVTDataCode1_Finish(atToolResults As ACTIVVTOOLSLib.IAVTToolResult)


  ' variable declarations

  On Error GoTo ErrorHandler

  ' procedure body

Exit Sub

ErrorHandler:
  Dim sTitle As String
  If Left(Err.Source, 11) = "ActivVTools" Then
    sTitle = "ActivVisionTools Error"
  Else
    sTitle = "Runtime Error " & CStr(Err.Number)
  End If
  Call MsgBox(Err.Description, vbExclamation, sTitle)
  Call SetAlarm
End Sub
```

By placing the following code at the beginning of the event handler, the actual result access is restricted to the *application mode*. With this mechanism you can setup the vision part of your application in the configuration mode without having to worry about run-time errors.

```
If Not AVTView1.ExecutionMode = eApplicationMode Then
  Exit Sub
End If
```

4.3.2 Accessing Evaluation Results

The evaluation results can be accessed similarly to the results of data code extraction; in fact, they are even stored in the same object. However, to access the evaluation results you now have to wait for ActivDecision to finish, i.e., create the event procedure

```
Private Sub AVTDecision1_Finish(atToolResults As Collection)

End Sub
```

! Note that **you will get a run-time error if you try to access evaluation results before ActivDecision has finished** (e.g., in the handler for `AVTDataCode`'s event `Finish`!

Because ActivDecision can evaluate the results of more than one tool, the event handler provides you with a `Collection` of tool results. The following code fragment searches the collection for the results of `AVTDataCode1` and "stores" them in `atDataCodeResult`, or exits if no results are found:

```
Dim atToolResult As AVTToolResult
Dim atDataCodeResult As AVTToolResult
Dim bDataCodeResultsFound As Boolean

bDataCodeResultsFound = False
For Each atToolResult In atToolResults
  If atToolResult.Name = "AVTDataCode1" Then
    Set atDataCodeResult = atToolResult
    bDataCodeResultsFound = True
  End If
Next
If bDataCodeResultsFound = False Then
  Exit Sub
End If
```

In Visual Basic .NET , the event procedure has the following signature:

```
Private Sub AxAVTDecision1_Finish(ByVal sender As Object, _
                                  ByVal e As _
                                    AxActivVTools.__AVTDecision_FinishEvent) _
                                    Handles AxAVTDecision1.Finish
```

Again, the tool results are encapsulated in the parameter `e`. They can be extracted as follows;

note the use of `VBA.Collection` instead of `Collection`!

```
Dim atToolResults As VBA.Collection
atToolResults = e.atToolResults
```

As already remarked in the previous section, tool names are prefixed with `Ax`, thus you must search for the results of `AxAVTDataCode1`:

```
If atToolResult.name = "AxAVTDataCode1" Then
```

You can query the overall evaluations at different levels, tool, ROI, or object:

```
Dim atROIResult As AVTROIResult
Dim bToolIsOK As Boolean, bROIIsOK As Boolean, bObjIsOK As Boolean

Set atROIResult = atDataCodeResult.ROIResults(0)

bToolIsOK = atDataCodeResult.Evaluation
bROIIsOK = atROIResult.Evaluation
bObjIsOK = atROIResult.ObjEvaluation(0)
```

Furthermore, you can access the evaluation of individual features like the data code of the object with the ID `0`, but also of tool features (e.g., the evaluation of the number of "bad" ROIs) or of ROI features (e.g., the evaluation of the number of objects) via the corresponding feature handle. In contrast to object features, the handles for tool and ROI features are available as properties of `ACTIVVTOOLSLib.AVTToolResult`.

```
Dim handleCode As Integer, handleBadROIs As Integer
Dim handleObjectsInROI As Integer
Dim bCodeIsOK As Boolean, bBadROIsIsOK As Boolean
Dim bObjectsInROIIsOK As Boolean

handleCode = AVTDataCode1.FeatureHandleCode
handleBadROIs = atDataCodeResult.FeatureHandleBadROIs
handleObjectsInROI = atDataCodeResult.FeatureHandleObjectsROI

bCodeIsOK = atROIResult.ObjFeatureEvaluation(handleCode, 0)
bBadROIsIsOK = atDataCodeResult.FeatureEvaluation(handleBadROIs)
bObjectsInROIIsOK = atROIResult.FeatureEvaluation(handleObjectsInROI)
```

The ActivVisionTools distribution includes the example Visual Basic project `evalaccess\datacode_evalaccess.vbp`, which uses these methods to extend the application described in the previous section. Now, ActivDecision is used to check the extracted data code as described in section 3.2 on page 30; in case the overall evaluation shows an error, the cause of the error is displayed (see figure 4.5). The example project is already configured, just start it and click the button `Run` in `AVTViewExecute`.

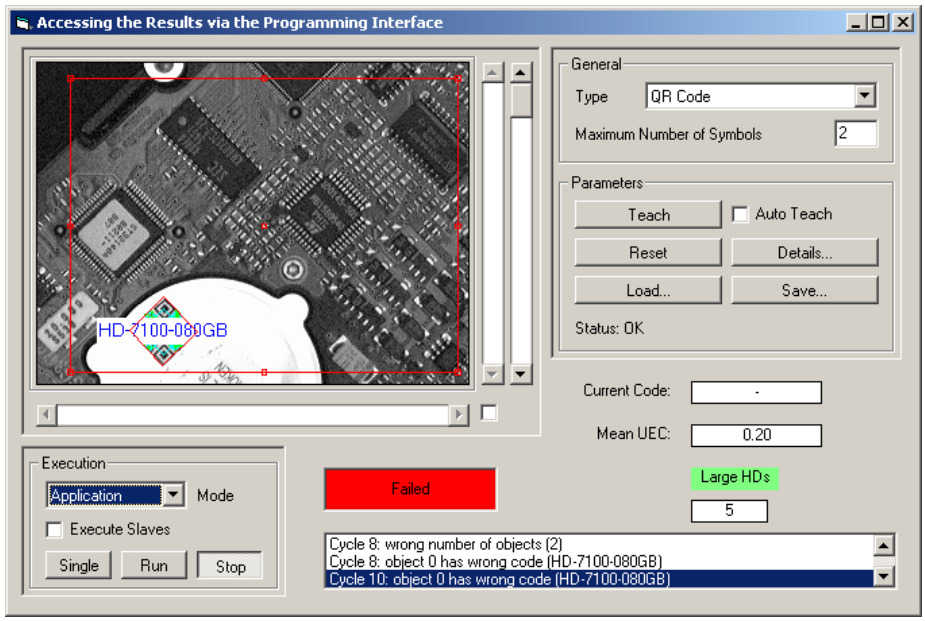


Figure 4.5: Accessing and displaying the evaluation results.

Besides accessing the evaluation results the project code contains additional functionality, which is explained briefly in the following (again only for Visual Basic 6.0!). First of all, the main `If - Then - Else` clause around the display of results of the data code extraction now tests the overall evaluation of `AVTDataCode1`:

```
If atDataCodeResult.Evaluation = True Then
  ' access and display data code extraction results
Else
  ' examine cause of error more closely
End If
```

In the example application, the only cause for `AVTDataCode1` being evaluated as “not okay” is that its (one) ROI has been evaluated as “not okay”. This in turn can have two possible reasons: First, that the wrong number of objects has been extracted (i.e., less or more than one). In this case, the following code fragment displays a corresponding message in a list box that indicates how many objects have been extracted:

```
If atROIResult.FeatureEvaluation(handleObjectsInROI) = False Then
  sErrMsg = "Cycle " & iNumCycles & ": wrong number of objects (" & _
            atROIResult.Value(handleObjectsInROI) & ")"
  Call DisplayMessage(sErrMsg)
End If
```

The error message also contains the number of the cycle in which the error occurred. The corresponding counter is incremented in the handler for `AVTView`'s event `CycleStart` which was introduced already in the previous section:

```
Private iNumCycles As Integer

Private Sub AVTView1_CycleStart()
  iNumCycles = iNumCycles + 1
End Sub
```

A second cause of error is that an object has been evaluated as "not okay". Again, a corresponding error message is created, this time containing the extracted data code. The following code shows how to access the indices of all objects evaluated as "not okay":

```
Dim badObject As Variant

If atROIResult.FeatureEvaluation(handleBadObjectsInROI) = False Then
  ' get all bad objects (cause: bad code)
  For Each badObject In atROIResult.BadObjectIndices
    sErrMsg = "Cycle " & iNumCycles & ": object " & badObject & _
              " has wrong code (" & _
              atROIResult.ObjectValue(handleCode, badObject) & ")"
    Call DisplayMessage(sErrMsg)
  Next
End If
```

Appendix A

Process Control Features

This appendix is a short introduction to the process control features of ActivDataCode.

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A.1 Introduction

The focus of the main part of this manual is about setting up and using ActivDataCode to read data codes in production environments. Another aspect of data code reading is to judge the quality of the data codes themselves. It is the focus of this appendix.

Using data codes as a labeling technique in industrial production flows and for retracement (tracking) purposes is all about automation: A proper use will result in an increase in efficiency and lower production and maintenance costs. Data codes of bad quality will work against these goals. Therefore, it is crucial that data codes used for these applications be of high quality.

The process of actually producing data codes and applying them to products or objects requires immediate feedback to rank their quality in order to guarantee a certain standard of readability. Getting this kind of feedback is known as data code *verification*. ActivDataCode can be set up to calculate common features used for data code verification.

A.2 Data Code Production

There are several methods to mark parts with data codes, some of which include

- ink-jet printing,
- laser,
- dot-peening,
- electro-chemical etch (ECE).

All these methods have their own advantages and deficiencies that influence their usefulness for different applications. Selecting the right method for your application is beyond the scope of this manual.

Usually, data code verification should be performed right at the marking station. Not only does it offer a way to control the overall quality of the data codes with the ability to reject bad parts, it also allows to monitor the wear and tear of the marking station itself and detect defects and other problems. This way, reliable labeling of parts with high quality can be achieved.

Images acquired for data code verification should be of high quality and higher resolution than actually needed for reading purposes. A module size of at least 5 pixels is recommended.

A.3 International Standards

There are several international standards that deal with data code verification. The fundamentals incorporated in implementing the process control features of ActivDataCode are mostly derived from the following international standards:

- ISO/IEC 15415 (Information technology — Automatic identification and data capture techniques — Bar code print quality test specification — Two-dimensional symbols)
- ISO/IEC 16022 (Information technology — International symbology specification — Data matrix)
- ISO/IEC 18004 (Information technology — Automatic identification and data capture techniques — Bar code symbology — QR Code)
- AS 9132 (Quality management systems — “Data Matrix” quality Requirements for Parts Marking)

It is very important to note, that ActivDataCode **does not fully implement these standards**. Thus, ActivDataCode cannot be used to verify that data codes are compliant with any of these standards. The listed standards require the calculation of the process control features to be based on a reference decoding algorithm. However, ActivDataCode implements its own decoding algorithm: Its main use is in heavy duty data code reading that is robust even under bad conditions, something that the reference decoding algorithm is neither capable of nor intended for. That said, the results from ActivDataCode nonetheless borrow from the listed standards and apply the same grading system. Therefore, they are very much comparable to results of data code verifiers actually implementing the standards.

A.4 Quality Grades

The quality grades derived from evaluating the process control features are expressed on a scale from A to D plus a failing grade F, with A representing the highest quality. The overall quality grade of a data code is the lowest grade of all its individual process control features.

A.5 Available Features

The calculation of the process control features is available from the `AVTDataCodeSettings` dialog. The results can be inspected in the `AVTDataView` dialog (see figure A.1) . Both dialogs are available by right-clicking on `AVTDataCode` in your application. In the following sections

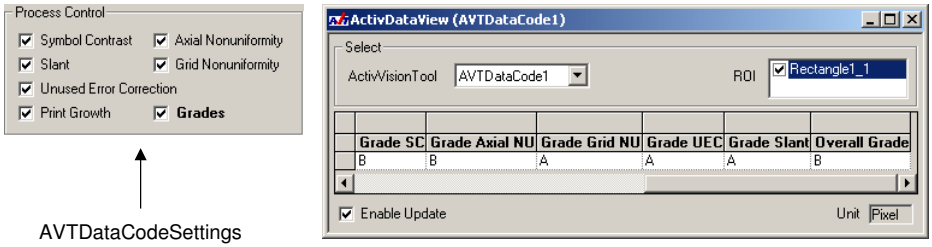

Figure A.1: Process control features.

the distinct process control features are introduced. Make sure to check ☑ `Grades` to get the quality grades of the features as well as the overall quality grade of the data code.

A.5.1 Symbol Contrast

This feature tests whether modules and zero modules (i.e., dark and light regions) of the data code are sufficiently distinct. It does this by calculating the difference of the highest and the lowest reflectance values. See ISO/IEC 15415 for more information on reflectance values.

Check ☑ `Symbol Contrast` to calculate this feature.

Symbol Contrast	Grade
≥ 0.70 (70%)	A
≥ 0.55 (55%)	B
≥ 0.40 (40%)	C
≥ 0.20 (20%)	D
< 0.20 (20%)	F

Table A.1: Symbol Contrast grading.

A.5.2 Slant

This feature quantifies the slantedness of a data code in degrees. Even though the grading is very strict, ActivDataCode can read data codes that are slanted up to 30°.

Check ☑ `Slant` to calculate this feature.

Slant in °	Grade
≤ 3.50	A
≤ 4.65	B
≤ 5.80	C
≤ 7.00	D
> 7.00	F

Table A.2: Slant grading.

A.5.3 Unused Error Correction

This feature quantifies the reserve in error correction that is still available after decoding the data code. A perfect data code requires no error correction at all, resulting in a value of 1.0 for this feature. The more defective a data code becomes, the more the inherent error correction needs to be applied to still be able to decode the data code. Please note that ActivDataCode only evaluates the total error correction capacity. For large codes with multiple independent error correction blocks, this is only an approximation.

Check ☑ `Unused Error Correction` to calculate this feature.

Unused Error Correction	Grade
≥ 0.62	A
≥ 0.50	B
≥ 0.37	C
≥ 0.25	D
< 0.25	F

Table A.3: Unused Error Correction grading.

A.5.4 Axial Nonuniformity

This feature evaluates the squareness of the data modules. Ultimately, it judges the aspect ratio of the data code, resulting in bad quality grades for shrinkage or enlargement in one direction (uneven scaling).

Please note that this feature is not used for PDF417 due to the variable aspect of modules.

Check ☑ `Axial Nonuniformity` to calculate this feature.

Axial Nonuniformity	Grade
≤ 0.06	A
≤ 0.08	B
≤ 0.10	C
≤ 0.12	D
> 0.12	F

Table A.4: Axial Nonuniformity grading.

A.5.5 Grid Nonuniformity

This feature quantifies the deviation of the modules of the data code from their ideal grid. However, a bad value might also be caused by problems with the finder pattern, in which case the "ideal grid" may not be positioned correctly.

Check ☑ `Grid Nonuniformity` to calculate this feature.

Grid Nonuniformity	Grade
≤ 0.38	A
≤ 0.50	B
≤ 0.63	C
≤ 0.75	D
> 0.75	F

Table A.5: Grid Nonuniformity grading.

A.5.6 Print Growth

This feature quantifies the uniformity of dark and light module sizes, i.e., how appropriately the modules fill their module boundaries. Depending on the print process of the data code, the desired module size may be affected. For example, in ink-jet printing the ink may bleed into the surrounding area causing the background modules to 'shrink'. The values are calculated for both horizontal and vertical module sizes (hence `Print Growth X` and `Print Growth Y` are reported). The value 0.0 correlates to a module size of 100%. Negative values denote module shrinkage, while positive values denote module growth. A quality grade is not calculated for this feature.

Check ☑ `Print Growth` to calculate this feature.